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49 S.

ON THE

SCIENCE AND APPLICATION

OF

GEOLOGY.

GEOLOGY AS A SCIENCE,

APPLIED TO THE

RECLAMATION OF LAND FROM THE SEA,

THE

Construction of Harbours,

THE

FORMATION OF RAILROADS,

AND THE

DISCOVERY OF COAL.

WITH AN ASSUMED

OUTLINE MAP OF THE GRANITE FORMATION OF THE EARTH.

◆

BY JOHN ROOKE,

AUTHOR OF "FREE TRADE IN CORN," AND "FREE
AND SAFE GOVERNMENT."

LONDON:
RIDGWAY, PICCADILLY.
MDCCCXXXVIII.

49 8.

PREFACE.

OUR thirst for history is insatiable. The Bible particularly never palls the mind in repetition, because it figures out to us the records of our physical, religious, and social histories in which our best interests are commingled not less for our mental consolation and moral instruction, than our delight. Nor is it less a cause of the interest excited by the sacred volume that it gives us information of the earliest existence of man, and of the world to which his mortal career is confined. The mind involuntarily reverts from the vast expanse of the estuary—to the dropping rill from whence the mighty river springs; and a contemplation of the immutable beauties of this earth would be unsatisfactory without we could accompany it by the earliest records of the chaos from which the Almighty hand called it into existence. [illegible] history of the world has, indeed, in [illegible] paid the researches of the learned, [illegible] or the visionary; and it has not [illegible] that they have cast themselves, [illegible] of imagination, from the solid [illegible] into the boundless ocean of [illegible] [illegible] and theories have exhausted [illegible] endeavours to assign causes for [illegible] beyond their means of [illegible] [illegible] to avoid such [illegible] [illegible] [illegible] before we shall [illegible] surface of the globe, and [illegible] the sequence of changes it has [illegible] ing from a chaotic state to [illegible] inhabited by a living world, [illegible] by man.

To the local history we [illegible] rocks in this place is [illegible] which partly originated the [illegible] Geology. In the year [illegible]

Hyde Clarke, Esq., the projector of the plan of crossing Morecambe Bay by a railway to form a connection with the isolated sea coast of Cumberland, the author made a survey and report on the practicability of effecting that object, and suggested a method similar to that detailed in these pages. This circumstance gave rise to a lengthened epistolary discussion with that gentleman on the nature and influence of tidal action in sedimentary deposition; and on the manner in which it was affected by the laws of conformation incidental to our globe. Having previously bestowed considerable attention on Geological systems, this correspondence awoke all the author's predilections on that subject, and induced him to persevere in their pursuit until the result of his labours attained the following shape. He was the more influenced in investigating Geological dispensations, as their solution materially affected an object of such vital interest to his country, and with which he has long been engrossingly occupied—the silting up and reclamation of estuaries from the dominion of the sea.

In his correspondence with Mr. Clarke, many incidents arose which gradually brought to light new and extended views on different portions of the topic; and the author has to express his obligations to that gentleman for suggestions which led to the developement of a general law of tidal action in the organization of the earth. Whilst the author has been enabled to lay before Mr. Clarke an important feature in the formation of harbours and silting up of estuaries, he has great gratification in expressing to that gentleman the pleasure he felt from a correspondence which rendered that an object of amusement and interest, which otherwise would have been solely an affair of dry unassisted investigation.

In framing a general scheme of railways for Great Britain, the author of the following work found that it also involved the vital interests of Ireland; and in carrying out a scheme thus enlarged, he found himself constrained, in order to give the entire subject a proper connection, to rest his data upon a Geological theory, somewhat more than he could have wished, however true that theory might be. At the moment of time when the body of this work had been printed off, and when the best means of information were unavailable, the Second Report of the Irish Commission on Railways was published. The uncommon ability and high national value of that Report are here fully and readily acknowledged. Though the author's scheme may in some features differ from that of the Irish Commission, yet, notwithstanding, he now ventures on publishing what he had previously said on the planning of Railways in Ireland; and the more especially as a modification of the two schemes may perhaps furnish the best practical course which could be taken. Such a remodification of those plans may be properly dispensed with in this place; and he shall here claim a fair attention only to the objects already described—to the central wealth of Irish territory, and the sum of its western population. He ventures to submit that these claim a central line, and immediate communication with Belfast.

The Irish Commission Report has noticed in passing, what the reader will find more extensively and exactly handled in the following pages. It is there observed, "Should a Railway communication be continued from Lancaster to Glasgow, which appears to be not improbable,"—and it is gratifying to meet with a remark so plain, from authorities thus able and influential,—"the mail might be forwarded, by that route, to Portpatrick for the north of Ireland, so as to reach Belfast, perhaps, in about 19 or 20 hours." In stating such an opinion, it is obvious that the Commission must have contemplated the construction of a line of railway from Portpatrick to North Lancashire, and another to Newcastle-upon-Tyne; on this view a railway from Portpatrick to Glasgow by the shortest available route, would be imperatively called for; and thus the main outline of the scheme of national railways described in the following pages, is amply justified. Not only is this so, but on the more perfect lines here suggested, and according to the Report of the Irish Commission, it would seem quite practicable to reach Glasgow, from London, in 16 hours, by the way of Whitehaven, (steam navigation from thence to Kirkcudbright,) and by the valley of the Cree, through the town of Ayr.

In the course of his researches the author has felt, that however many have passed over the field, there is still something left for him to glean; and if, in presenting a general theory, he may have committed some errors in detail, he trusts that, like his predecessors, an amendment of such errors, by future Geologists and men of science and experience, may add to the progress of more exact knowledge. He shall rejoice, therefore, in contemplating the results of the future, in the hope that his humble labours may prove useful in contributing to the perfection of some happier author. He cannot but perceive that in the anxiety of speculators to attain a better system of Geology, they had been too often induced to discard the only certain data which they possess in the revelations of the sacred volume. That volume, however, in the true spirit of its letter, composed in an oriental language, yet definite in its applied sense, the author of the following pages believes to be founded in exact truth.

However defective his own efforts may be, the author humbly relies upon the spirit of his motives as an excuse for the attempt made to render Geology more exact and plain in scientific classification. If the five orders into which he has thought proper to divide Geology, be considered either inapplicable or erroneous, he is ready to stand corrected. Yet as an humble follower of an inspired penman, he must have good reasons assigned for consenting to any change of either principles or deductions. Because he believes Divine revelation to be true and unassailable. For he feels that both the science of Geology, and its professors, must gain a more intimate connection with the sacred and conservating influence emanating from the records of Holy Writ.

In conclusion, if this work should fail to be of utility to the general mass of his fellow-beings, the author nevertheless trusts that he may have contributed some mite to the advancement and welfare of his native country. He means well; and whatever doubts may be entertained of the efficiency of his labours, he is conscious of having been animated throughout by good-will towards man, and a humble desire to vindicate the power and wisdom of God.

Akehead, Wigton, Cumberland,
August 1, 1838.

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GEOLOGY.

CHAPTER I.

ON GEOLOGY AS A SCIENCE.

TRUE science is a classification of phenomena, conceptions, and ideas, concerning such matters of thought as become the subject of notice, reflection, and examination. It is indeed a prescribed form contrived in aid of the human understanding. Science is therefore a simplification of our ideas, for rendering abstruse and complicated questions familiar and plain; suited alike for general and comprehensive views in the application of our thoughts, or descending to particular and trivial details. Considered in such a light, it is an instrument by which information is readily gathered; we are thereby enabled to communicate what we know more distinctly, and order and exactness in investigation are preserved. Subjecting the various branches of our reflection and forethought to well constructed forms, rays of true light are separated from the confused elements in which they previously lay concealed; and a power is thus framed by human invention, like unto infinite wisdom itself, which constantly works out extended designs according to easy and applicable rules. To distinguish sound science from that which may be fanciful and spurious, is therefore worthy of our careful solicitude and consideration.

The elements of science, or the materials of which its frame-work is composed, should always be clearly defined, and easily separated from each other, so that grounds of wrangling about constituent parts should not remain a subject of dispute. In determining on various orders and classes, the schemes of any science should be exact and obvious. Pure science may be indeed well illustrated by referring to the alphabet of language,—and in the language of enumeration, to the cardinal signs by which quantities are expressed. Though these be composed of nothing but generalised fictions, yet by their conversion in use to particular objects, our conceptions assume definite and comprehensive forms of intelligence, whether extending even to infinitude, to minute and detached objects, or to a communication and recording of our ideas. Indeed, by a species of typical transfusion, the verb is rendered significant in language; we learn its right use, and its meaning becomes exact and known, when stripped of its abstract features in an applied sense. Such symbols even aid investigation, lead to the invention of fresh instruments of thought, and contribute to our store of knowledge, though they be but abstract signs and mere fictions. Because, when applied, they lose the quality of abstraction, and become the essential signs by which actual being is denoted and made known. In short, they then lose the property of generalization altogether, and assume that of particularization, the practical object for which they have been designedly framed. Pure science is so far aptly illustrated. It enables us to bring our thoughts out of darkness and confusion, and place them in order, harmony, and light. Contrived by intelligence in the first place, its purpose is a help to intelligence itself, and in knowledge a means to an end.

Spurious science, producing erroneous deductions, is equally obvious, as shown in the delusive doctrine of the Rent of Land, originally propounded by the late Mr. Ricardo, and since adopted by Political Economists as an echo. Assuming that land is naturally worn out by cultivation, which is true as regards improvident cropping, yet erroneous so far as profitable and provident husbandry are concerned, he made it appear that a wilderness exceeded in fertility and productiveness an old cultivated country like England. Upon these false premises he proceeded to frame the outlines of Political Economy—overlooking the important fact that commerce, the division of labour, the progressive accumulation of capital, and the application of available arts and science in an old cultivated country, have raised the productive powers of the husbandman individually above what it is possible to attain, or is effected, in any newly discovered land. It is so far obvious that the elements of which any science may be compounded ought to be distinct and truly applicable to an elucidation and classification of facts.

As Geology proposes to investigate the changes which the earth has undergone in its progress towards a state of maturity, so the elements of science must be drawn from the sequence of its fabrication and modification, in configuration and products, which originated with primeval designs, and the application of physical forces, according to which God made the earth by his power—established the world by his wisdom, and stretched out the heavens by his understanding. In six days God completed his works. The first five days, or periods of constructing the earth for the abode of man, give at the same time in science the best Geological division of the subject. The sixth period is the state of man, in which his busy affairs are the subject matter of history; and in which the Creator has taken rest, so far as the construction of our earth is concerned. But whilst the work of mundane creation remained in his hand, to say that the processes were comparatively slow, and by either chance or necessity, would be impious, and a denial of the infinite power and wisdom of the Deity. In all the vast and various institutions of system within system, each of which is perfect within itself, and adapted to that within which it exists and works,—in those splendid models of supreme wisdom, when rightly understood, we observe one common simplicity in design, harmony in construction, and comprehensive exactness in even the most trivial matters. In tracing designs so multifarious and perfect, shall we view the earth as an exception to the general rule here noticed, and by no means a complete system within itself, progressing from a state of embryo to maturity? A negative deduction would be irrational. We must therefore endeavour to trace the true history of the earth's construction in the various stages of progressive change which it has gone through in producing those wonderful ends, wherein so many beauties and uses are displayed. The earth is a system working within itself, and though non-sentient, framed on principles of perfect design and mechanism, as if it were a sentient being. This is so far undeniable. The deduction cannot be withheld. To the order of creation we must appeal in the construction of Geological science.

An inspired writer has informed us that the earth was made in a sequence of events. The evidences, we may yet gather from its present state, attest the faithfulness of the Sacred Interpreter; and all subsequent philosophers agree, that it has been subjected to many changes in composition and figure. On such premises we shall proceed to describe the formation of the earth in an humble endeavour to give Geology more exactness as a science. It is out of materials, drawn from the true order of creation, that we purpose giving to Geology its appropriate alphabet, and shall proceed in our task accordingly. On the just application of those incidents we must depend for a correct interpretation of the laws by which they are regulated, and which constitute science.

In its diurnal course the earth turns round, and we enjoy day and night accordingly. Periods of labour and rest have just limits assigned them. Arrangements so simple and effective in the system of the universe, are true models of exactness in detail. On tracing the progressive steps by which an allwise God has constructed the earth, proceeding from first causes to ultimate consequences, we must admit that an easy and provident chain of principles pervades the entire scheme to which we owe the wonderful ends brought about. Provident and economical means obviously run throughout God's works in general. These even apply to man as a necessary law of being, mitigated by the endowment of reason, and a just balance in his moral temperament. All other creatures of God's goodness are subject to the same universal regulations of order, harmony, and design. In the investigation before us these impressions shall be our guide.

Though we are unable to comprehend the origin of matter and mind, we must at the same time view them as instruments and means in the hands of Infinite wisdom and power. Our proper task is therefore to adore and humbly trace them; gaining a right acquaintance with incidents which belong to, or flow from, a state of being offered to our notice. They are. But whilst we have hitherto failed in mastering the economy exercised in the humblest system of Nature's handyworks, it would be gross folly to proceed in the investigation of still higher mysteries. Our means of knowledge are limited to incidents, laws, and facts, which belong to perfect systems in the eye of Providence. Even these are confused and dislocated in the limits of the human understanding, although we know that they work according to regular and systematic laws.

By experience and observation, and by just inferences, in which the progress and action of Nature's laws are carefully watched, we begin to design and frame modes of thought, which enlarge the extent of intelligence in man, augment the sum of his happinesss, and promote a Creator's designs, manifested as they are in Christian peace and blessedness. Such, indeed, is the conclusion to which true science leads; a consolation which defies sophistry, and before which false ideas fall prostrate.

CHAPTER II.

ON THE PRIMARY FORMATION OF THE EARTH.

We may assume that the earth in its primeval form consisted of a cluster of matter or nebulæ, driven out of universal fluidity by the ordinary laws of gravitation, and finally concentrated in an embodied mass, that repulsed the forces of fluidity, and afforded a place of rest to some of the denser and unshapen atoms that had previously floated about in the regions of endless space. Motion and rest are therefore antagonist powers on which organic being greatly depends. An accumulated mass having been driven from the neighbouring parts of the Planetary System, by more active forces, which occupied the free and open regions of infinite space, gravitation fixed and steadied the earth in its orbit on ordinary laws. For as bodies in motion acquire additional force and power of pressure corresponding to their velocity; and as bodies in a state of rest possess no force and pressure except their intrinsic density, so light and active atoms have a necessary tendency to drive inactive atoms into dense and motionless masses. Why a stone falls to the earth, and sparks are prone to fly upwards, is an exhibition of those opposing forces, according to which solids and fluids may be equally qualified to resist and drive off each other. The former by their density; the latter by the additional force they gain from activity, and the influence which atoms in motion exercise upon each other. Hence unshapen and sluggish atoms are necessarily driven into nuclei or clusters, and acquire a power of resistance according to the aggregate force by which they rest upon and cling to a common state of being; and those powers which are adequate to drive them into dense masses, are equally qualified to fix and steady them in their position eternally, until being is prone to take and preserve order and form.

Thus the solidity of the earth commenced, by its becoming a place of rest to which masses of sluggish atoms were thus driven, fabricated on systematic principles,and cemented together on cohesive laws. Solidity was separated from fluidity, and organic harmony had a beginning. A system so perfect and orderly within itself, though non-sentient, could not spring from chance. Organic form, indeed, implies mental agency and design. Every fact we are acquainted with verifies the inference to which this truth leads. But as we are totally unable to comprehend how mind operates on matter, and to what extent it either is or has been applied to the organisation and preservation of the universe, so are we bound to accept an obvious conclusion, though unable to penetrate the mysteries by which volition is able to interfere with and regulate physical forces. We observe the planetary system working in perfect order and harmony, and witness the effects produced. Yet first causes are hidden from our view. If we are unable to master the working of lower systems, which we can investigate intimately, how shall we comprehend those which may be equally intricate, and also lay at an immeasurable distance? We may, therefore, assume that bodies in motion have an inalienable tendency to fall into disorderly courses, and to establish an unmitigated chaos, unless rectified and steadied by overruling omnipotence and intelligence.

As regulated action originated with, and sprang from eternal volition; as physical laws were preserved and combined with that state of rest which the system of the universe discloses in detail, it becomes the province of science to pencil out the progressive changes to which the earth has been subjected in past periods of time. Here we reap the proper elements of Geology, frame a plain alphabet for science to work with, and gain a more intimate acquaintance with dormant truths.

Reconstruction in the configuration of the earth is a leading feature which Geology proposes to describe. The alphabet of science must, therefore, be sought in a sequence of changes. From the beginning of the earth, and up to the present time, the mobility of matter and a chemical assortment of atoms, have been the ceaseless agents of reconstruction on our globe, in addition to animal industry, decay, and resuscitation. Violence and chaos have been subdued, and order and harmony have arisen in obedience to Divine commands. Even adverse elements have been converted into economical uses. Unless an admission so requisite be made, philosophy is but an idle dream. When we accept the interposition of the Divine will, however, —which we have no evidence to gainsay, and a multiplicity of proofs in verification of,— we by no means deny, but confirm the limitation of our researches to strictly physical laws. Though the interference of human intelligence, in directing his busy toils, has changed the very features of our globe, and progressively converted an original wilderness into a smiling land teeming with the nutritive products of the earth, yet the fact by no means withdraws the influence of physical agency, when placed under the direction of the human will. Such distinctions certainly define their due limits. Every act of mind,—and we may well ask how can mind act at all, whilst we know only that it does so,—may be placed in the category of supernatural agency, inasmuch as it controls and imparts a new direction to physical forces. Though working by the help of physics, yet exercising a controlling agency at the same time, an instrument of power is evinced which interferes with natural laws, and modifies the very face of the land in an industrial country like England. When we detect organic evidences belonging to an inert body such as the earth, which contains no mental system of self-regulation within, and therefore no means of self-organisation, the interference of omnipotent volition is proved so distinctly, that organic being in general is traced to a common origin and cause, which is ever active in the preservation of order and harmony throughout the whole universe. If a non-sentient body exhibits proofs of an organising influence, it would be irrational to deny a similar interference having originally moulded the clay of animated nature, and breathed the breath of life into its nostrils. Neither neglecting these considerations, nor straining them to a mere verbal purpose, in place of distinct ideas, we shall learn how obvious and simple in the economy of the universe true physics are. Geology must be accordingly limited to purely physical results, constantly worked out on omniscient principles.

The earth is composed of two distinct classes of materials. Solid bodies in a state of rest, or having a tendency to such a state; and fluids in the most extended sense, possessing an opposite tendency, or mobility and action. Rest itself, however, is but an exhibition of a universal law, according to which bodies possessing kindred affinities, form, and density, are naturally driven together, and amalgamate with or impinge upon each other. Not by assigning to them any supernatural law of the attraction of gravitation; but by laws consimilar to those which prevent the sea from encroaching on the dry land of the earth. The same rule of being, therefore, which applies to the earth as a body, applies to the universe. Fluidity and solidity constitute the two opposing elements, which it is our especial object to consider and expound in connexion with each other. Placed in a constant state of action and re-action, solids are either driven more compactly into aggregates, or dispersed by antagonist forces for a season, and again recollected together on physical laws.

But this is not enough. There is a God. Harmony and organic action are the decrees of heaven. This admitted, Geology acquires an appropriate starting place, which is undeniably authenticated; and from whence cause and effect have worked out the ends originally designed by infinite wisdom.

In the beginning the earth was without form and void. And God said, Let there be light, and there was light. Here Geology, as a science, commences; and the series of changes it has gone through conformable to the sequence of creation, give its proper alphabet. Fluidity is an obvious law of nature, which, if we include volatility in this term, is ever actively at work above us, around us, and even beneath our feet. Chemical agency and action are equally apparent, and continually give rise to progressive changes.

It is an admitted fact, that the temperature of the earth is higher, as far as it has been penetrated, proportionally from its surface downwards. It may be justly inferred, that this augmentation of heat increases on some law of progression towards its centre. If the most active and divisible particles of matter, or atoms of a spherical form, be engaged in driving dense and mishapen atoms, which are less readily divisible, into inert masses, the internal action which these masses generate within themselves, naturally occasions their dislocation, change of position, and eventual recomposition. To these conclusions the atomic theory necessarily proceeds. A high tendency to divisibility in some atoms, and the reverse in others, would lead to an opinion that active atoms are prone to insinuate themselves into the cavities of less compact ones.

As restlessness and activity are a common law of matter, in conformity to that regulated action for which eternal wisdom has provided,—if the earth were a solid ball, and acquiring internal heat progressively to its centre, assuming a ratio which facts sanction, it would finally burst asunder to and from that centre. Being seems a paradox indeed, according to which the contending powers of rest and activity reciprocally contribute to their regulation and control. Though the laws of weight and pressure in bodies be determined by their density or solid materials when at rest, those powers are also multiplied by the impetus given them and the projectile velocity acquired. Hence the pressure of a single ounce in a state of activity, or elastic fluidity, may be adequate to displace a ton weight at rest, and propel it forwards. In conformity to this common law of being and physical forces, sparks fly upwards, rain descends from the heavens, a pellucid ocean rolls beds of shingle and sand on shore, and leaves them in a state of repose. There is no law of the attraction of gravitation required in these instances, distinct from the ordinary forces of matter; but the velocity or rest of atoms more or less divided surpassing the forces of one another. Nor is it less an ordinary law of gravitation that dense clusters of atoms should repulse active ones conformable to the square of their surface; and active atoms drive sluggish ones into masses. It is so far a great law in physics that fluids and solids should not agree; that they have a mutual tendency to displace and separate from each other, and occupy distinct spaces in the universe, as divisibility must be the freest in open space, and the least so when atoms come to rest upon each other.

When we speak of water and the atmosphere, fire and electricity, and of the sun as a generator of heat, we cannot strain our conceptions beyond atoms in a state of greater or less divisibility and activity. When we observe electricity cut its awful path through resisting elements, and descend on earth with force prodigious and speed indescribable, we catch a glance of that regulated action, over which an omnipotent God rules. Neither chance nor necessity could ever bridle powers so mighty. Supreme wisdom and design have. A truth so unanswerable is verified by the most palpable evidences. The various masses of matter, therefore, which compose the solid parts of the planetary system, have been driven from their wandering courses through the regions of infinite space, and brought into perfect order and harmony by an Omniscient designer. Disturbing forces have been converted into the instruments of regulated action, resting upon those repulsive masses to which divisibility impels them.

In the beginning of the earth, solidity and fluidity had a necessary tendency to separate of themselves. The great deeps covered the face of the whole earth accordingly. This is an obvious and ordinary law in physics. It is not less plain that the earth holds its diurnal course from west to east. Would the waters which then covered the face of the earth move at the same pace? Certainly not. It would have been at variance with gravitation. If a loose rim be placed upon a spindle put in motion, the rim moves in an opposite direction to the spindle on which it is placed. The ordinary contact of bodies in motion determines this physical law. A tidal current which overspread the earth, with a tendency to accumulate on the equator, would therefore flow from east to west. We may fairly infer that the line of separation between these opposite motions, would not be exactly preserved. A large mass of loose and semifluid materials, composed of the different earths, would be in a state of constant agitation, and subjected to attrition, placed as they were between the opposite motions of two antagonist forces,—solids driven together, and fluids necessarily falling asunder. Hence the outer rim of the earth, that on which the great deeps rested and turned, would be chiefly compounded of loose materials in a finely divided state, extending to a considerable depth, and resting upon a base comparatively solid and at rest. In the primeval state of the earth, and previous to induration having been perfected, the effect of internal force lifting up the lower parts of its body, would by no means alter the configuration of the earth. In truth, it would be figureless, and remain a rounded watery waste, as the materials so elevated would speedily be swept away, and submerged again. At the same time, the lower parts of the earth's body would have a tendency,—agreeable to chemical and mechanical forces, and viewed as a complete electro-chemical apparatus,—to take a crystalline form according to their kindred properties, and assume true order accordingly.

Time working out such processes in nature as were intended would cement and indurate a crystalline mass, which thus composed the lower part of the earth's body, or the outer crust, which philosophers, probably in truth, assign to that body. In this preparative state of Geology, adapted to a future state, the earth would seem to have undergone an instant and decided reconstruction, which gave it a figure and form it still retains. Internal heat and force, which chemical affinities are prone to generate, especially in a laboratory constructed on omniscient principles, seem to have rent the earth to its centre; and upheaved the granite formation at once, either within or above the range of the earth's semi-fluid rim, beneath which it had previously laid concealed. No partial operation could have effected these results, which still remain distinctly and extensively mapped out for our observation to dwell upon. The proud waves were stayed; bars put upon them, and doors set to let out their rage. Nor would it have been consistent with omniscience, in the possession of adequate forces and means, to have adopted a less general and effective course. Nor would the flux of tides, which we shall explain more fully by and by, have retained the uniform evidences that yet belong to them. Here we commit no mistake. Facts shall decide.

From the Strait of Magellan to Behring's Strait, and by the Rocky Mountains to the Arctic Sea, an unbroken chain of granite, subsequently strengthened by the sedimentary depositions of newer formations, stands the barrier of the Western World; and running along the entire length of its western shore, the dry land of the New World is found on its eastern line, and within the broad space so admirably protected by mighty breakwaters, stretched out in the most orderly manner. Had these stupendous works been wrought in disorderly operations, its joinings would have been incomplete, a confused force must have been employed, the chain must have been broken, the figure of the earth faulty, and the distribution of dry land exceedingly different. The origin of the New World is indeed stamped upon those remarkable features, which its figure bears.

On the eastern shore of Behring's Strait the granite formation recommences. From thence, traversing the central regions of the Old World, one of its termini is washed by the Sea of Marmora. Recommencing again on the European shore of that sea, and taking the line of the Alps, it terminates on Cape de la Hogue. It then traverses Great Britain, in a few isolated patches, from south to north, or may be often concealed beneath subsequent formations, yet exhibited enough to evince its presence. On the Naze of Norway it reappears, and running for a thousand miles in a north-eastern direction, it finally terminates on the shores of Lapland.

Resting on these base lines of the original dry land of the earth, in both the old and the new worlds, there are many lateral branches of the granite formation, which we shall here omit in detail, noticing at the same time some of the peculiarities of its composition, and the influence it has eventually exercised in determining the configuration of the globe, and fitting it for the reception of animated nature.

The appearances of granite denote a crystalline origin, cemented and indurated in its primary position, without having either undergone igneous fusion, or fluid attrition. Either of which must have necessarily obliterated the traces of those granulations its appearances exhibit; the one by blending it in fused masses, and the other by rounding off its angular points. Granite indeed is a primeval sand-stone, composed of crystalline grains. Igneous action, less intense than fusion, combined with pressure and chemical influence, are at the same time quite adequate to account for its high induration and compact cementation, and that too in no lengthened period of time; whilst chemical affinities, the properties of crystallization, and electro-magnetism, may satisfactorily account for the appearances which felspar, quartz, and mica exhibit in the composition of granite. Prepared in the bowels of the earth for a subsequent purpose, without being either subjected to igneous fusion or active attrition, an internal force has been generated, which instantaneously upheaved chains of breakwaters, constructed of materials which had substance enough to stem and turn the great waters of the earth, and prepare an adequate protection and secure foundation for dry land to rest upon and accumulate.

Though it be admitted that the body of the earth primarily took a semi-fluid form, it by no means follows that it was in a state of igneous fusion. If fluidity in matter be necessarily attributed to fusion, then the Thames is on fire. The absurdity of the inference refutes itself. Mud is not in a state of igneous fusion. And why may not the primary form of granite have been the original mud of which it seems compounded, decomposed, and blended together in grains on electro-chemical principles? Igneous action unquestionably commenced when induration had sufficiently prepared the repulsive elements of solid and fluid matter; and when the earth had been fitted up within and without as a comprehensive chemical apparatus. Here the violence of collision, and the tendency of atoms to divisibility, elastic mobility, recomposition and repose became the instruments by which an organic world has been so splendidly designed and fabricated. In truth, the earth has been organically constructed, and prepared for working out the ends designed by infinite wisdom and power.

Nor is the exhibition of the granitic formation in unstratified or in stratified forms a question of material importance, as the superior beds of that formation might undergo stratification ere it was upheaved from its primary foundations. Besides, it is obvious that in the early stages of deposition, vast masses of the primary formation would be necessarily commingled with primary depositions; whilst subsequent disturbing forces have also contributed to produce those dislocations in the different formations, which involve the details of Geology in mystery; but are speedily discerned by a correct system of generalization.

Subsequent volcanic action, since the date of a primeval process, we readily admit, may have therefore materially disturbed the granite formation incidentally, or partially subjected it to a state of igneous fusion. Yet the concession by no means detracts from the theory previously laid down. The beginning of the heavens and the earth, when the spirit of God moved upon the waters, and light instantaneously supplanted darkness, as described by an inspired author, is quite consistent with the theory here ventured upon; even though our deductions were wholly drawn from existing facts.

Dry land having appeared, the waters of the earth having been gathered together, and a sedimentary process having begun, protected by breakwaters constructed of granite,—to describe subsequent events becomes a plain and onward task. All the consequences now lie on the surface of our subject.

A granitic arm is fixed on central Asia, and stretched out along the western shore of Hindostan as far as Cape Comorin; protecting and adding an important limb to Southern Asia. Another granitic chain separates the valley of the Ganges from that of the Burrampooter, leaving an opening which finally leads to a junction of these mighty fresh-water drains. Recommencing again, the same chain runs through the Birman Empire to Sincapore, and protects the isles of the Indian Ocean. Another chain of granite resting on the vast ridge of the Taurus, traverses Arabia, and re-appears on the opposite shore of Africa. There dividing itself into two great branches, one of which protects the eastern shore of that quarter of the globe, and turns round the Cape of Good Hope; the other branch, by the mountains of Kong and Douga, is stretched across central Africa.

Returning to the base line of Asia, a chain of granite commences at the sea of Aral, resting its terminus on the northern promontory of the Ural mountains, and completing a barrier which traverses Asia from north to south, as well as from east to west. Another arm, fixed on central Asia, protects the Chinese empire; and finally branches out to the Strait of Formoso and the Bay of Cormorin.

In the New World, resting on the great western base line, a number of granite arms protect the vast plains of North and South America. A well-defined line also affords security to the West Indian isles—consimilar to those of the Chinese sea, and the isles of the Pacific Ocean, except where coral reefs have subsequently served a like purpose.

New Holland may be considered as a detached Continent, fortified against the ravages of the great ocean, by primary breakwaters composed of granite, the same as the rest of our globe. Indeed, some few instances of more recent igneous fusion admitted, which are easily distinguished from the granite formation, the future depositions of the earth owe their original security against the ravages of the sea, to those effective breakwaters which the granite formation so amply exhibits, and without which land neither has nor could have appeared—the exceptions here given being first admitted.

The different lines of the granite formation here described, represent the leading outlines of the primary formation, which have decided the figure eventually taken by the earth. The accompanying map not only shows the primeval figure of the earth at a glance, but gives a skeleton of its form in detail. Affording likewise a ready illustration of the inferences we shall draw from the premises and facts already given. Observing at the same time, that unless some adequate power had stemmed the tidal wave of the earth, dry land could never have had a beginning.

In giving a map of the granite formation, we readily admit that much is assumed, that it is a free outline only, and necessarily imperfect in details. Whilst such defects detract from the merits of our work in giving an imperfect delineation of the granite formation, the leading features of that formation are sufficiently ascertained to bear out the first premises we rest thereon; and we may safely proceed on the ground that granite is the primary formation, that it originally stemmed and decided the future tidal currents of the earth, strengthened by primary depositions in lineal and corresponding courses, that it is neither a marine deposit nor a product of igneous fusion; but has been uplifted from the bowels of the earth by internal force, indurated and cemented as it is now found. So much either granted or denied, the facts we shall unfold in the course of these pages, must in future lead Geologists either to establish our first principles by authentic and extensive evidences, or refute them altogether, by laying down the exact spaces occupied by the granite formation, its various elevations, and sedimentary additions, coming at fair conclusions in how much it has been overlaid and extended by newer formations of which it has been the nucleus. All admit granite to be the oldest formation. What then is its origin? It is admitted to be composed of indurated crystals in a great measure; and is not crystallization a result of chemical affinities? It is but a sandstone differing in the form of its granulations. The theory here put forth is important in Geological science, inasmuch as it asserts that the deposition of most of the dry land of the earth has been primarily protected and sheltered in its formation, from the ravages of the ocean, by reefs, ridges, and mountain chains of granite.

Such a theory contains nothing forced, irrational, nor in the slightest degree inconsistent with physical laws; but in perfect accordance therewith. The means assumed are in every respect adequate to the purpose effected. The earth burst its cerements under an accumulated action and pressure of laws inherent in nature, and an organic world appeared, more perfect in design, and more finished in details than the most accomplished engineer could have planned. Better adapted in frame-work, more elaborately constructed, or more simple in process, it could not have been. Internal force was generated in the bowels of the earth, on purely physical laws, as designed by omnipotent and omniscient volition, and dry land was instantaneously cast from the great deeps. We here beg for no process of primeval fusion; we ask not for ages on ages to cool a fused mass, but accept an instant and ordinary law of nature. Truly might an inspired writer say, "Let there be light, and there was light." No description could have been more coincident with the act described. The interference of Almighty will and power become unavoidable admissions. As well might we deny those faculties in man; and the application of mind and body to the designing and fabricating of works of art. Fully conscious of the seat of our own designs and works, shall we deny or mistrust similar powers in the hands of an omnipotent God, when we behold so many evidences of his handywork? Even so skilfully contrived, and full of perfections, that we are unable to trace out the wisdom of works so justly framed. Chance never could have struck out a skeleton of the earth, divested of foreknowledge and design, so orderly, refined, and comprehensive as that which the map here given discloses to our view.

During a period of primeval darkness, and "before the mountains were brought forth" it may be fairly assumed, as previously stated, that the earth was a rounded ball, the solid parts of which held its diurnal course from west to east, that its tidal current flowed from east to west, and bore along its stream vast layers of the earths in a semi-fluid state. According to these terms, unsteadied by determinate provisions, the earth probably presented its face to the sun accidentally. So that a specific order of seasons, day and night, and other periodical provisions, would fail in being regularly observed on the face of the globe. Instantaneously, however, the earth burst those cerements in which it previously lay entombed, "the mountains were brought forth" and organic order and harmony began.

Two distinct ranges of efficient and continuous breakwaters, shored by elaborately constructed limbs, were thrown across a portion of the globe, which poised its gravitation, and subsequently provided an equator. Regular day and night commenced as a consequence. For if the earth lost an equality of balance, when more land was raised on one side than on the opposite side, its movements became steady in perpetuity, without at all disturbing the exactness of its gravitation as a membe of the Planetary System. Henceforwards the earth may be said to have turned on its Northern Pole, or that that pole stood in the direction of the highest resistance, and as up and down in the regions of infinite space, by no means alter the laws of gravitation, so the application of a balance to the earth's orbit evinces the omniscient wisdom of Providence. Stated returns of day and night, winter and summer, and the flow and ebb of tides, were determined. The application of ballast to the earth, by an excess of land being thrown on the Northern Hemisphere, like a vessel floating on the bosom of the ocean, steadied its position, and a regular return of seasons was secured for every clime on the Globe. In obedience to a provision so simple, by turning constantly on its Northern Pole, the earth preserves an equator with unfailing certainty.

With these considerations in view, with a map of the skeleton of the earth before us, so extraordinary in its features and outlines, and in which the Eastern and Western Hemispheres seem to be equally balanced, we are constrained to adopt one of two theories. That physical laws in themselves are necessarily either capable or incapable of securing the most perfectly regulated action, independent of volition and design, or not. A negative conclusion is obvious. They are totally incapable of gaining order and harmony in themselves. Too limited in knowledge, however, to comprehend the available means employed, the vanity to which our nature is prone, and our gross ignorance on the enlarged economy of the universe, we have a deplorable tendency to raise doubts on what we are unable to comprehend distinctly. We may dabble in a few trivial details, yet failing in an universal connection of natural laws, we are apt to overlook those considerations of order and design which lie on the surface of events. In directing our speculations to the existence of an omniscient God, the most enlarged and perfect frame-work, constructed on true mechanical principles, are alone admissible. Like Mr. Malthus on the Principle of Population, some Geologists would seem almost to rashly impugn the wisdom of the Deity, overlook the tendency of the universe to more perfect harmony and perfection, and argue accordingly. Decay is certainly a law of nature. But resuscitation is in some measure regulated by the ratio of that decay. Passing over a truth so unanswerable, philosophers will tell us that this coast may be speedily ravaged by the sea, that we may be suddenly swept away by a deluge, and are momentarily in danger from extended volcanic action, because we yet witness such incidents obtaining in a limited degree. Their mistake is plain.

Viewing the earth as a body exhibiting a perfect system within itself, and constructed on mechanical principles, we shall apply such organic evidences to the universe inferentially, and fearlessly pursue a train of investigation, which may be faulty in some respects; yet as a whole lead to a better acquaintance with eternal truths. In the economy of extended fluidity, electricity would appear to be deeply concerned. What are the channels through which the electric power moves? They appear to be as well defined in physics as the channels of any brook or river. When the forked harbinger of heaven's mightiness descends from on high, we are fully assured how resistless its power, and matchless its speed. Awful and imposing as it appears, we learn from the phenomena that it cuts itself a way through opposing elements, which instantly repair the breach made by the electric stroke. Immense force is therefore actively at work, and that force must be renewed again ere a second rupture can be effected. Why then is iron a conductor of a fluid power so active and subtle? Because the atmosphere, as shewn by the phenomena exhibited, is a compact fluid mass, more rare, and of course less dense, than water; and because the conductor ruptures this fluid body, and imparts more active freedom to an agent so subtle and all-pervading the atmosphere as electricity is.

In casting the eye upon the skeleton of the earth, coupled with the theory of fluid action previously described, we may be allowed to infer the physical arrangements by which a magnetic current works; and the beautiful economy in nature for which polarity provides. Regular channels for the diffusion of electricity, and the due saturation of the atmosphere with that active fluid, would seem to be intimately concerned with the economy of animal life. Hence the same infinite wisdom which balanced the earth in its orbit, has also diffused those active elements on which respiration depends. Until the granite formation was upheaved from the bowels of the earth, its tidal current checked, its orbit steadied, and the electric fluid disseminated by a plan so effective, animal life could have had no regulated being. We shall in this place assume that one of the economical purposes of polarity is the constant diffusion of electricity throughout the atmosphere by a horizontal distribution, which converts the elements of lightning, by its regular and safe dilution with aqueous fluids, into an ingredient of which a respirable atmosphere is compounded.

To balance the earth in its orbit, bridle the tide wave of the ocean, convert it into an instrument by which dry land was made, saturate the atmosphere with the elements of vitality, and by an upheaving of the granite formation, suspend that atmosphere on high, was a conception and a work suited to the wisdom and glory of God;—turning at the same time in the direction of Polarity, the gulf stream of the Atlantic, and the oceanic currents of the Pacific and Indian oceans as an aid to a corresponding movement. Of course, we conclude that the various chains of granite, which the map of the primary dry land of the earth describes, are electrics, that afford a ceaseless supply of electricity to the atmosphere in a safe and efficacious manner. The more we contemplate the vast economy of the universe, indeed, which such a scheme in the framing of an organic world discloses, the more are we led to a conclusion that the primary land of the earth is admirably suited to collect, circulate, and saturate the atmosphere with the elements of respiration and life; probably contributing to cool and carry off an excess of heat from the torrid zone, like the gulf stream of the Atlantic ocean, and other oceanic currents, which is absorbed in the arctic circle, and returned again to its original starting place cooled and salubrious.

If lofty chains of granite arrest the descent of electricity, and convert it into an ingredient of which a respirable atmosphere is compounded, it may be inferentially assumed that electricity, directed by the finger of Providence, had previously lent its aid to the disentombing of the primary formation. We even possess the means, through the medium of observation and reflection, of collecting and applying an electric force. Shall we deny its attributes in higher, wiser, and infinitely more efficient hands than ours? By no means. It would be presumptuous, erroneous, and impious, and convert philosophy into nothing more rational and enlarged than a mystic riddle.

We have now to consider the influence of granitic breakwaters, as already sketched out, in deciding the future figure of the earth; its various products and fruits; the direction of oceanic currents; the formation of seas, bays, and estuaries; and how the very winds of heaven happen to blow from any and every point of the compass. Transporting the argosies of commerce in all directions, across every sea almost, and purifying the atmosphere by a constant process of amalgamation, so as to preserve its healthy composition.

In the economy of the universe, action and rest are the antagonist principles, which constantly resist and modify each other. Repulsion, the agent of action, is unceasingly checked and bridled by cohesion, the agent of rest and resistance. We shall explain. Previous to the uplifting of the granite formation, whilst it lay concealed in the womb of the earth during a season of embryo, a vast mass of materials had no common resting place; and commingled with the superincumbent waters which overspread the whole face of the earth, in a state of semi-fluidity, continued to float promiscuously from east to west in disorderly courses. No sooner were efficient dikes constructed of granite thrown directly across the entire tidal wave of the earth almost, than the mighty extent of these semi-fluid materials were either driven upon, towards, or brought to positions of natural rest amidst the dead water which these dikes occasioned. Accordingly, as resistance and rest check the velocity of bodies in a state of fluidity, the laws of gravitation operate, and lighter but more active matter drives that which may be heavier and more sluggish into aggregates or masses; and they remain stationary, owing to the misshapen and inert atoms being deprived of the quality of mobility. A bed of shingle driven before a flowing tide, having no principle of mobility inherent in itself, cannot return by the force of its own powers; and remains a deposit on the point to whence it is so driven, unless the same active agency which propelled it forwards, should return it back again. As the impelling force, though less in specific gravity than the shingle propelled, derives its excess of pressure from its velocity added to its weight, and naturally flows back again of itself, so a process in which deposition goes on indefinitely through any period of time, may continue until the lighter but more active waters of the ocean, clear its bed of loose and sluggish materials. A consimilar law applies to polarity, though in a form and manner too subtile for our detection, unless from its effects evinced by analogy and more tangible operations. The attraction of gravitation, indeed, divested of resisting forces, would seem a fable. It appears plain, therefore, that a current composed of active atoms is continually carried towards the Northern Pole, which influences and directs the magnetic needle, like the current of a river determining the bearings of a log of timber floated along its surface.

The repulsive laws and influence which inherently belong to motion, together with the cohesive qualities of rest, acting and re-acting on atoms differing in form and volume, which may be either sluggish and adhesive, or exceedingly active and divisible in themselves, are truly shown in the train of consequences which followed the mighty dislocation of the earth already described. The Globe no longer a rounded ball on which an even surface was preserved, but an upheaving of the granite formation brought about, as shown in the map and skeleton of the earth here gone before; we have next to consider and illustrate the results on oceanic currents which this important event produced. It has been previously explained that the original elevations of the dry land of the earth had their general bearings fixed upon, and were gathered to a focus in the direction of the North Pole, so as to determine a set of electrical movements in horizontal courses. We shall presently show that the main oceanic currents found upon our globe, run in perfectly consimilar directions. With organic evidences before us so orderly and harmonious in design, who shall wantonly deny the especial interference of Almighty wisdom and goodness in the fabrication of the earth? And such interference once admitted undeniably, we necessarily cannot stop again at any assignable limits of God's care and interposition in the affairs of this his mundane creation. The terms being either an admission or the denial of a Godhead.

An eastward motion of the earth decided upon, a huge mass of semi-fluid materials existing, which had been, in a primeval state of the world, carried along the currents of the great deeps, and the tidal wave of the very globe itself having been checked and driven out of its natural course by immense lines of granitic breakwaters, we shall now trace these several bearings in settling the direction and position of oceanic currents both generally and in detail.

The figure of these granitic breakwaters in its main outlines is exceedingly simple and comprehensive, being a continuous chain all but thrown completely around the North Pole from Cape Horn, on the 55th degree of west latitude, south; to the Cape of Good Hope, on the 33rd degree of east latitude, south, as illustrated by the map already given. Consequently, the earth turning on its axis, and having a tendency to swell up its waters in a westward course on the equator, the general tidal current of the globe is completely driven from its natural bearings along the equator; as the only space known to be wholly clear of land on a parallel thereto, lies between the 55th and 75th degrees of south latitude. On the northern hemisphere, projected on the plane of London, we find within its area, most of the two Continents, which form objects so conspicuous in the geography of the earth, along with the Atlantic Ocean, all but edged around by those Continents, except upon its southern boundaries where it lies in full and free communication with the Pacific Ocean, and the South Pole standing over against its central line. The southern hemisphere, as projected on the plane of London, with the exception of part of South America and New Holland, is mainly occupied by the great Pacific Ocean: and around the South Pole we find three bold projections of land, Cape Horn, Van Diemen's Land, and the Cape of Good Hope.

On such terms, those three projecting points of land, absolutely force the tide wave of the earth upon the South Pole, and thereby establishes a common centre; on which the whole waters of the globe finally turn; and from whence they are distributed into oceans, seas, and estuaries. Here we find the primary tide wave immediately divides itself into three secondary ones—the Pacific, the Indian, and the Atlantic Oceans.

The tidal wave of the Pacific Ocean, gathered together from a water-shed on Capes de Saint Roque and St. Augustinc in the Atlantic, from Van Diemen's land, and the Indian Ocean, sweeps along and from the entire western shore of the New World, from Cape Horn to Behring's Strait, where it all but touches upon the Arctic Circle, and as far as Cape Lopatka, the most southern headland of Kamtschatka. It then runs to and terminates upon that part of the Eastern shore of the old World, which lays between Cape Lopatka, and the Strait of Malacca, gradually returning again through the Straits of Malacca, Sunda, Torres, and other outlets, by the Indian Ocean; and along the Eastern Shore of New South Wales.

The tidal wave of the Indian Ocean is supplied from a current which runs westwards along the Southern shore of New Holland; and from the several straits and outlets which lay between the northern shore of New Holland and Malaya. It then runs into, and terminates upon the north-west shore of the Bay of Bengal; and also, into the Arabian Sea, terminating in the Gulf of Persia; and again running southwards on the south-east coast of Africa, it turns the Cape of Good Hope.

From off the Cape of Good Hope, one of the main oceanic currents of our globe is collected together; and impelled into the Atlantic Ocean, it then takes the western coast of Africa to about the 20th parallel. This great current next holds its course across the Atlantic, and on the western Coast of America abutts on Cape de Saint Roque, a point on which these waters in some measure shed themselves, running southwards in the direction of Cape Horn; and northwards along and on the north-east coast of South America into the Gulf of Mexico. Here it turns. Next flowing through the Gulf of Florida, taking a course parallel to and upon the south-east coast of North America, from whence it runs in the direction of Iceland and Spitzbergen. Flowing into the Arctic Sea, which is all but edged completely about by land, it necessarily turns in the Polar deeps; and by the western coasts of Norway, Scotland, Ireland, Spain, and Africa, returns southwards again to the point from whence it set out, to recommence its vast and ceaseless round, impelled by the prevailing force of the currents of the Pacific ocean, and the diurnal revolutions of the earth.

In theory as in reality, the regulations and distribution of the three secondary tide waves into which the waters of the earth divide themselves, impelled from their common centre on the South Pole, like pulsation from the heart of animated nature, is wonderfully harmonious. The great deeps themselves turn upon the Poles of the earth;

and communicate from the one to the other, and across the Equator in the most orderly manner. The highest science could suggest nothing more perfect. For we are to trace and attribute such mighty phenomena to omniscient wisdom. The very orbit of our planet itself, is neither more securely nor organically contrived. Are we to conclude that all this wisdom is but self-design, in conformity to laws necessarily inherent in physical forces? Then more wonderful still, all matter must be endowed with a spirit of intelligence, for the interference of intelligence, is here manifestly necessary. While we are unable to speculate at all on the intelligent attributes of the Godhead, and as we are equally unable to deny the existence and power of intelligence in the direction of material bodies, so our only rational course and rational duty, is belief in the infinite wisdom and dispensations of an infinitely bountiful and gracious God. It would besides appear but a fair deduction, that electricity works in conjunction with tidal currents in cooling the earth where too hot, and warming it where too cold.

The vortical current of the Atlantic Ocean, in returning from the Arctic Sea to the equator, throws off a set of tertiary tide waves on the coast of Norway, which would appear to add considerably to the salubrity of the British Isles, aid their means of navigation materially, and to have been at the same time intimately concerned in determining the Geology of those isles. One runs into and fills the North Sea, terminating in the Strait of Dover. Another, after running down the western coast of Scotland, enters the North Irish Channel, and runs into the Irish Sea. Here it is divided into three branches, one takes the western shore of the Isle of Man, and terminates in the Bay of Drogheda; the rest sheds itself into two branches on St. Bee's Head, and then flows northwards up the Solway Frith, and southwards into Morecambe Bay. A third tertiary tide wave is thrown from off the returning gulf stream on the south-west coast of Ireland, and forms the South Irish Channel; sending off branches into the Irish Sea, the Bristol Channel, and the British Channel. The first of these branches scours the eastern coast of Ireland on the south, and runs northwards as far as the Bay of Drogheda, at the same time shedding itself on the Isle of Man. Another of these branches meets the wave of the North Irish Channel in Morecambe Bay. That which runs into the Bristol Channel, flowing upon a comparatively limited area, raises the tides of that channel unusually high; and the tide-wave of the British Channel meets that of the North Sea in the Strait of Dover, or from off Dungeness, accordingly as different winds prevail.

The figure of the granite formation having settled the bearings of these various tide-waves, coincident with the laws of gravitation, as determined by the eastwards revolution of the earth upon its axis, and in reference to the several positions of its dry land, we have next to consider where those semi-fluid materials have been driven and deposited, which, previous to an uplifting of the granite formation, had overspread, beneath the tidal wave, the whole surface of the earth, and constituted a sort of loose rim, which moved in an opposite direction to the fixed base on which that fluid rim rested. Consequently, these materials were in a constant state of active attrition. If such a process extended a mile in depth, or half a mile, or but a quarter of a mile only, all over the earth, the final deposition of a flowing mass of materials so vast, and in addition to the primary formation, which had been lifted up from the bowels of the earth, are sufficient to account for the extent of dry land which is now found on the surface of the globe.

A glance on the figure of the granite formation, in conjunction with the courses of tidal currents just given, explains and confirms the uniform laws on which a main portion of these semi-fluid materials have been deposited on various spaces of embayed water. Pure physics decide the problem truly. Atoms of the highest divisibility and spherical in form, are necessarily the most fluid and active; and have more force added to their volume and density than atoms less divisible, misshapen, and naturally sluggish in action. Bulky aggregates of matter by a consimilar law are necessarily driven into cohesive masses, which resist or repulse active atoms by their compactness and density. Hence dense atoms are driven together, or attract each other, and more active atoms the reverse. The semi-fluid rim of the earth, therefore, when the granite formation had been uplifted, was mainly carried from the western and open escarpments of that formation, and deposited on eastern shores which were open to the approach of a western current; or those loose materials were swept within the great vortical current of the Atlantic, and deposited in the various spaces of embayed water which laid upon its extended shores. By tests so severe must our leading theory either stand or fall.

In verification of a tidal law so plainly announced, the entire western shore of the New World, from Cape Horn to Behring's Strait, is denuded and stripped of Neptunian deposits, except such as have gone to fill up the cavities of and strengthen the primary formation; whilst the eastern shore of the Old World, from Cape Lopatka, in Kamtschatka, to Siam, along the eastern shore of Hindostan, and on the north-west of the Gulf of Persia, is equally as remarkable for a great extent of deposits and fathomable water, as the opposite shore of the Pacific Ocean is for denudation and unfathomable water. The immense valley of the Amur, those of Hoang and Kian, the Hong, the Kion Long, the Burrampooter, the Ganges, the

Euphrates and Tygris, and others, are full of deposits to the very edge of the ocean. The valley of the Indus, and that of the Nerbuddah may at first sight appear exceptions to our rule. Sheltered by Hindostan, however, shut up westwards by Arabia and Southern Africa, and flowing in a northern direction, those vallies are naturally composed of a series of depositions, from clay slate to alluvial debris. The western shore of Hindostan is as completely denuded, because it is open to the Arabian Sea on the west, as is the western shore of the New World. The Ghauts being composed of granite, strengthened at the same time by primary deposits, and laved by the Arabian Sea, are striking confirmations of the theory previously given. As a tide-wave sweeps along and from their western escarpment, so are they mainly bare in Neptunian deposits coincident with the plainest laws of tidal action. Again, the south-east shore of Southern Africa does not hold a position likely to retain deposits, and its comparative denudation followed as a matter of course.

Whilst the eastern shore of the Old World, therefore, from Cape Lopatka to Cape Comorin is all but uniformly distinguished for Neptunian depositions, the rest of the shores of the great Pacific Ocean, westwards from Cape Comorin to the Cape of Good Hope, and from Cape Horn to Behring's Strait on the western shore of the New World, and as far eastwards as Cape Lopatka, are all but denuded of the entire series of depositions. Why? Because the tide-wave of this great ocean either drove its loose materials on the north-east shore of the Old World, and deposited them in its vallies, or swept them within the influence of the great vortical current of the Atlantic Ocean, from whence they could no more return. And in casting the eye around those extended shores, which lie beyond or without the Atlantic Ocean, it is quite startling to observe how extraordinarily they are denuded on one side; and how strictly they have been driven to the termini of its tide-wave on the other. Such are the fruitful and wide-spread vallies of China and Hindostan.

The Cape of Good Hope and Cape Horn stand the mighty portals of the gates of the Atlantic, through which the best portion of the dry land of the earth has been driven to a state of deposition. In rounding the Cape of Good Hope, the tide-wave of the Indian Ocean would naturally disburthen itself of a huge mass of deposits on the side of Southern Africa. The vallies of the Niger, the Gambia, the Congo, and the Orange River, all attest the peculiar formation of Southern Africa. The mighty current of the Atlantic, carried westwards by the Cape of Good Hope, ere it entered the wide-spread basin of that ocean, gave rise to an immense space of smooth water on its eastern edge, or on the side of southern Africa, up to the 10th degree of north latitude, and on the western termini of the Kong mountains. Hence the spacious areas of its vallies, as the granite formation of central Africa runs about 35 degrees more westwards than the Cape of Good Hope. Turning in the gulf of Guinea, the great Atlantic current took a north-west direction, and drove a series of depositions on the eastern shore of the New World, as remarkable for their amazing extent, as its western shore is for denudation and a deficiency of plains. Facts so striking and uniform, unanswerably confirm the theory of the granite formation here adopted, as shewn in those tidal consequences on deposition, which followed the great dislocation of the earth.

Oceanic action in rounding the Cape of Good Hope, would have a decided tendency to throw off a line of deposition in the Southern Atlantic, stretching from the Cape of Good Hope as far as the plains of the Senegal and the Gambia; and the returning gulf stream from the Arctic Sea, running as far south as Cape Verde, have decided the figure and geographical boundary of Africa along its western shore, from the Straits of Gibraltar to the Cape of Good Hope.

In a similar manner the angular figure of the New World is fixed on Cape de Saint Roque. The main current of the gulf stream running in the direction of Mexico; and a counter-current crossing at the same time, and taking the direction of Cape Horn, have brought forwards depositions on

Cape de Saint Roque, and shallowed the waters of the eastern shore of South America in general. Indeed, a single glance around the basin of the Atlantic must convince even a trivial observer that, whilst its outer rim is all but denuded of Neptunian detritus, from Cape Horn to Behring's Strait, the vast shores found within the gates of the Atlantic Ocean, display a remarkable extent of fruitful and inconceivably spacious plains; composed of Neptunian, diluvial, and alluvial deposits. The very figure and relative positions of this great basin, seem as rightly constructed for gathering depositions, which have been scoured off the Indian and Pacific Oceans as omniscience itself could have devised.

Nor can the figure of the Atlantic ocean, with corresponding lines upon its eastern and western shores, as if formed for fitting into each other, be viewed in any other light than the results of tidal action on deposition. Even the breadth of this great ocean is but a channel of currents in perfect resemblance and windings to a mighty river casting up alluvial depositions upon its banks. Here we discover a pool, and there a shallow, according as its course has pressed heavily on one point, and slacker on another.

An extended chain of granite traversing central Africa from east to west (though granite may not be essential to this great ridge) and fortified by the spine of the world on its south-east frontier, Africa naturally acquired those depositions through which her chief rivers run westwards, which seems an exception almost to the rest of the globe. The Nerbuddah is also an instance of a considerable river flowing westwards, being sheltered by the Ghauts of Hindostan, and thereby calculated to gather depositions. These evidences show, therefore, notwithstanding the western current of our globe, and its tendency to depositions on eastern termini, that incidents may arrest the prevalence of a general law, and decide oppositely in some few instances.

On the eastern side of South America, as might be anticipated according to the theory previously given, immense areas of depositions are formed. The course of the river Amazon extends 3100 miles; that of the river Paraguay 1900 miles; the Oronoco 1380 miles; and the river Saint Francisco 1100 miles. Contrasted with these mighty inland drains, there is not a single stream on the entire western shore of the New World, which runs so much as 200 miles inland; and rarely more than 100 miles from the shore. Facts so decided as these need no arguments in support of our theory. The inferences are self-evident and conclusive. Even the single valley of the Amazon extends over a space of 1500 miles in breadth, by 2000 in length, reckoning the various tributary basins of which it is the outlet; and so gentle is the acclivity of this spacious valley, that vessels fit to cross the Atlantic can ascend the river 2500 miles inland.

Where is this great basin of depositions placed? On the very point where the relative configuration of the Old and the New Worlds, impelled the gulf stream through the gates of the Atlantic ocean, and cast up its detritus on shallow shores. Scouring away and propelling forwards the loose materials of the widely spread Indian and Pacific oceans. Not to say how fully the vallies of the Paraguay, the Oronoco, and Saint Francisco, coincide with the theory of the earth here elicited. Nor can a doubt remain why the eastern and western shores of the New World are so different in their geological phenomena. The earth's motion is the cause thereof.

Commencing with Florida, and taking the circuit of Cuba and the West Indian Isles, a primary chain is thrown up, which at first sight appears favourable to the collection of depositions. As the gulf stream flows right across this line, however, all natural defences are broken through, and a large area of depositions is thrown into the great valley of the Mississippi. Had a complete opening in the granite formation existed, between the Gulf of Darien and the Bay of Panama, sufficient to let out the gulf stream, the figure of the earth might probably have been exceedingly different. Inasmuch as the Atlantic might have consequently been walled across from Cape Verde to Florida; and so left Europe without the means of navigable egress southwards and to the rest of the globe. Had the gulf stream escaped through such an opening in the centre of the New World, it must have taken its course directly into the Pacific ocean, widened its own channels, and disburthened itself of its depositions along its north-east edge or boundary. On the contrary, the great pivot of America being securely walled up by granite, and the great current turning in the Gulf of Mexico, this mighty stream finally scoured out the spacious channels of the Atlantic ocean and the Arctic sea, drove its debris on the south-east shore of North America, and the north-east of Europe, leaving the navigation of the Atlantic free southwards; and around which most of the active nations of the earth are clustered so happily.

The shores of South America, on its eastern line, are peculiarly shallow; and the Gulf of Mexico is remarkable in possessing few good harbours. The gulf stream turning within its shores occasions unfathomable water on its centre, and along with the influence of cross currents, a tendency to bar its rivers prevails; and at the same time every vacant space of water is silted up which a good harbour might occupy. No sooner has the gulf stream reached the shores of Cuba, however, than the Havannah presents one of the finest harbours in the world. The shores of the Gulf of Mexico, having in some measure disburthened the waters of the gulf stream of drifted silt, and pressing on the limited channel of Florida in its eastward course, a good depth of water is attained, and depositions taking the south-east shore of North America, a natural harbour of the best description is consequently formed and preserved by ordinary tidal action. The figure of Florida in connexion with the Allegany mountains have determined the depositions which cover a large area on the south-east parallel of those mountains, the pride of the United States of North America; also trending in the direction of Lower Canada and Newfoundland. In Upper Canada the granite formation is unusually prevalent; and it scarcely seems palpable on a glance what the formation of the valley of the Saint Lawrence may have been. It would at the same time appear that the depositions of the vallies of the Mackenzie and Coppermine rivers, have been driven into those spaces by a current turning in an unknown part of the Artic Ocean, eventually flowing along Baffin's Bay, and at length running into the general current of the gulf-stream. Probably holding the ceaseless circuit of Greenland by a Polar channel, or coming in part through Behring's Strait.

The depositions of the great valley of the Lena, that of the Jenisei and Oby are exceedingly obvious. The prominent features of the Ural mountains, projected forwards in the direction of the North Pole, naturally collected depositions on the immense areas which these vallies occupy.

Resting on central Asia as their common base line and foundation, no law of fluid action can appear more evident than that on which those extensive plains are fabricated.

We now come to the consideration of that extended plain, which is bounded by the Ural mountains on the north-east, the Alpine chain of mountains on the south-west, resting its base line on central Asia, and enclosed on the north-west by Norway and the North Sea. Its area, from east to west, may be estimated at full 2000 miles in length; and, from north to south, at 1500 in breadth. The general levelness of this spacious plain is not the least interesting object connected with its peculiar features. In proof how decidedly depositions have had a tendency to drift on this great plain, the original cradle of freedom in the western world, and now the land of industry and arts, were a log of timber pushed into the tidal current from off Cape Horn, it might make the circuit of the Pacific Ocean, and by the southern shore of New Holland, or the Straits of Malacca, Sunda, or Torres, reach the Cape of Good Hope. There it might start for the Gulf of Mexico, turn in that Gulf, pass through the Gulf of Florida, and be found embayed in the White Sea. Drifted pine also carried down the Mackenzie River, might make its way through Baffin's Bay, round Cape Farewell on the shores of Greenland, and be found embayed in Obskaya Gulf. Accordingly, almost all semi-fluid materials, which previously to the uplifting of the granite formation, floated unceasingly around the globe, were subsequently to that event driven on places of natural rest, and stood a chance of being finally deposited on the great European plain. Carried along the western shore of Norway northwards, they turned the northern shore of Lapland, abutted upon the Ural mountains in the east, and were swept within the area of those extensive levels, which are enclosed and protected by the Ural mountains, central Asia, the Caucasus, the Taurus, the Alpine chain of Europe, the granite formation of central France—that of Great Britain, and the extended Norwegian chain of mountains. On such terms Great Britain stood in a Geological gap, the eternal protector of an eastern plain; that Fatherland whence social wisdom originally sprung.

Destined in future days to afford that refuge to freedom, which has been denied her in her native cradle, Great Britain again stands in the gap, the expounder and fabricator of that rational liberty and social regeneration, which can never die in her discreet and able hands.

Had Great Britain, and its twin abuttment, Ireland, been omitted in the primary formation—these natural keys of Europe, placed on the Atlantic Ocean, and its widely spread plains, like the Indian Ocean, and the Gulf of Mexico, must have been an extended sea, exhibiting Carpathian rocks and Alpine summits. It is evident that earthy matter drifted around Norway and Lapland, on their northern shore, was naturally entrapped as it were without a chance of escape, and deposited on the broad area which lies between the Ural mountains on the north-east, the steppes of Asia on the south, and the Alps on the south-west.

When we view the relative positions which the mighty breakwaters of Norway, the Ural, central Asia, the Caucasus, the Taurus, the Alps, and central France occupy, with the British Isles in advance—twin sisters on the bosom of the Atlantic, we cannot doubt the origin of the extended plains, which those eternal and sublime works enclose and protect. Works which truly proclaim the designs of Heaven's high purpose and omniscience. Moreover, viewed in a light so striking, with the Norwegian chain of primary mountains as a regulating centre, enclosed by granitic barriers on the east, the south, and the west, as here described, and yet entirely open on the side of the Arctic Ocean, we trace the boundaries of Europe, designated one of the quarters of the globe, and exactly include within its limits the provisions and operations which essentially belong to a single space of tidal depositions.

The evidences here given, correspond so truly with the general theory already propounded, that the inferences deduced would appear unanswerable. To lift up the granite formation by simultaneous action from the bowels of the earth,—solid, and strong, and eternal in endurance, is by no means inconsistent with igneous energy. Forces which we know to exist, are every way adequate to the results assigned. A principle of progressive saturation by electric powers may have gradually accumulated, organized by the infinite wisdom and foreknowledge of God, (and how shall we deny the employment of an agency so consistent with the harmony of the universe?) until the primary skeleton of the earth appeared in order and form eternal, and in wisdom perfect. Even suspending and turning off into horizontal courses of polarity, which now impart the elements of vitality to a respirable atmosphere, those powerful agents which were previously employed as instruments of geological fabrication and organic being; steadying the earth in its orbit in the mean time.

Let these speculations be as fanciful as any one may choose to call them, proofs are given which are so plainly on the surface of our subject, that they may be fearlessly left to assert their claims to authenticity. To point them out is enough.

The uniform fulness of depositions within the great circuit of the Atlantic Ocean and all its subsidiary seas, and their omission on the outer girdle which encloses this spacious area of the earth's surface, (or what may be figuratively called the living body and bosom of the globe,) except on eastern escarpments, present a body of immutable facts which cannot be set aside, and place the eternal signet of truth upon our general theory. Speculations upheld by evidences so general and undeniable, are at once conclusive. From Cape Comorin, on the southern headland of Hindostan, along the shores of the Indian Ocean to the Cape of Good Hope, and from Cape Horn to Behring's Strait, laved by the Pacific Ocean, on the whole line of this mighty girdle, which may be said to encircle the best portion of the habitable globe, we find the primary formation comparatively free from depositions; and even beyond the Strait of Behring, as far as Cape Lopatka, in Kamtschatka. Nor are the evidences here adduced the less remarkably exact from Cape Lopatka to Cape Comorin, which describe what is properly the eastern shore of the Pacific Ocean, in presenting a continuation of the most splendid and fruitful plains on the face of the earth.

If the base line of a triangle be laid down, resting on Cape Lopatka to the embouchure of the Indus, and the apex of such a triangle fixed on New Zealand, assigning the depositions on the eastern shore of the Pacific Ocean, as lying within an area so described, we shall find a space equal to about 4500 miles square, chiefly occupied by either land or fathomable water; and as much probably as one half of this space may be attributed to land formed by tidal depositions. Yet immediately to the eastwards these depositions, or on a line stretched northwards from New Zealand to Cape Lopatka, we find an unfathomable space in the Pacific Ocean, laying between such a line and the western shore of America, with scarcely any land appearing, which exceeds the extent of land and fathomable water found to the eastwards of New Zealand and Cape Lopatka. The deduction is unanswerable. An extent of denudation so enlarged and complete, immediately bordering upon corresponding depositions composed of land and fathomable water, give a plain answer. The results of an eastwards motion of the earth, and consequently a westwards current of the ocean, flowing also in a curved line northwards and southwards, almost from pole to pole, are here distinctly demonstrated.

Hence, we ask no postulates or first premises; but base the whole system on incontestable physical laws, which are not left to conjecture or hypothesis, but may be determined by actual results. Having shewn that the various formations are derived from fluid action, determined by fixed granitic pivots, we shall in the ensuing chapter show the progress of the depositions which are spread over these barriers of the world, and how by an omniscient Providence those wonderful works are thus preserved, as the labours of the painter are protected and beautified by a coat of varnish.

CHAPTER III.

ON DEPOSITIONS, AND THEIR VARIOUS FORMATIONS.

WHAT has gone before shews a violent and sudden revolution to have occurred on the face of the primeval earth. We have now to trace the consequences of this revolution in detail, and frame an alphabet for Geological science out of the leading changes which the earth has since undergone. At whatever period, or whatever series of matter we examine the ingredients of which the main substance of the earth is composed, we find clay, sand, and limestone the prevailing materials out of which it has been constructed, and brought into an organic form. It has, therefore, assumed its present modifications and properties by having gone through a train of processes, chemical and mechanical, which have brought to light the earth we now behold. The primarily solid portion of the earth, the granite formation, by no means differed materially in the elements of matter, from the semi-fluid rim which rested thereon. Alumine, silex, and calcareous earth, which last commonly contains an admixture of 45 per cent. of carbonic acid in combination formed the main substance of both the primary and the secondary masses of matter, out of which the earth has been framed. These being very differently compounded, in distinct periods of the earth's progress to maturity, both chemically and mechanically, it is by detecting these differences, and ascertaining the peculiar incidents which belong to each Geological era, that we frame a correct order of science and nomenclature. So far matter was in but two distinct states or classes, solid and fluent.

No sooner had the granite formation been lifted above the waters which previously overspread the whole face of the earth, or even lifted within the base line of those waters, or of a semi-fluid layer beneath them, than a prodigious commotion necessarily ensued. As it may be fairly assumed that the semi-fluid rim of the earth, at that instant, was somewhat equally distributed over its solid face, so its admixture with the waters of the earth contributed to suspend them above their subsequent level; and but small spaces of the primary formation must have then been elevated above the level of the great deeps. Yet the influence of these stupendous breakwaters necessarily extended to their base in stemming and turning tidal action. However mightily the Neptunian trident might lave over them, yet they would check the great tidal current effectually, and determine the course of depositions according to physical laws. The altitude of the tide-wave at this important juncture is a question of some moment.

In discussing this material question, inasmuch as a faithful outline of Geology may be involved, the figure, composition, and height of our British mountains claim especial attention. Have they been materially raised in height, have they undergone obvious changes in features, or has their composition undergone any essential conversion since the era of their deposition, by the influence of subsequent volcanic action or not? We say not. The Cumberland mountains are a fair instance. None of their highest peaks are composed of granite. In summit heights they are comparatively equal as a group. In figure they are almost uniformly sloped and regular in form; and they generally lie in lines that take a western and eastern direction—blunt on the east, and tapered finer off to the westward. Even the plain of Carlisle and Wigton, situated on their northern base, and the progressively ascending ridges which cover that base, are all disposed in comparatively regular parallels, taking corresponding directions from east to west, with the mountains that stand along their southern edge. Evidences so regular are at once adverse to an admission of material volcanic action since the date of their original deposition. Again, have they been produced by igneous fusion, and vomited forth like so many Etnas? If any one of them has had such an origin they all have, since their composition, lines, and features are mostly uniform. These coincidences are so much at variance with the phenomena of running lava, and craters on their summits, that a fused, and igneous origin is inadmissible. We shall, therefore, conclude that they are sedimentary depositions, which would infer the elevation of a tidal wave when these mountains were formed, exceeding the present oceanic level by upwards of 3000 feet, as many or most of their summits attain such an altitude, and none of them more than 3800 feet.

A question may be here raised which is material to sound science. Are these mountains depositions at all? We shall treat this question as decided by what has been just said. They are depositions, and primary in their class, yet secondary in formation. It is true that in reference to a newer formation which immediately succeeded, they are placed between the primary formation and the secondary depositions, and are in so much a transition series. Yet shall we conclude that such a transition formation shall have no place assigned between the primary series and the secondary depositions? Nothing more unscientific could be proposed; and yet such a classification has been introduced into Geology. We might as well say that the number two shall hold no distinct place in enumeration, because it constitutes a transition point in notation between one and three; and by merging two into one, two shall be excluded, and one and three constitute the primary and secondary signs. Three shall thus take the place of number two; and number two shall be merged as a separate sign. Mr. Fairholme,* with a clearness which distinguishes him as a writer, has placed such a division of geological series in a distinct light. "The *mineral formations*," he observes, "have been divided by Geologists into *four* different classes, termed primary, transition, secondary, and tertiary." For reasons so plain, we shall uniformly class the primary depositions as the secondary formation; and the secondary depositions as a tertiary formation.

In proof of the deposition of the secondary formation, it is acknowledged that the constituent elements of indurated clay and clay slate are similar. The secondary formation accordingly comprises a class of rocks, the deposition of which immediately followed the uplifting of the granite formation, from gniess to greywacke included, and mainly preceded the creation of animated nature. This arrangement of geological classes includes a complete series of the three earths which compose the main portion of the body of our globe—clay, sand, and limestone—either in clay slate, indurated clay, or diluvial clays, associated with primitive limestone, carboniferous limestone, and lime in composition with diluvial beds—along with the corresponding compounds which belong to each distinct class. For though fluid action, or Neptunian laws might separate these earths with tolerable exactness, yet they were not the less likely to remain compounded together in general instances.

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* "Mosaic Deluge;" published by Ridgways, Piccadilly.

According to such a classification, the secondary formation rests upon the primary formation, and neither includes carboniferous limestone nor millstone grit, which belongs to a subsequent era of the earth's organisation; namely, to the secondary depositions, or the tertiary and sandstone formation, of which they are commonly the base. Though this classification may for a time confuse the language and terms of Geology, yet as these ought to signify the statements we wish to make, the different orders of creation we propose to explain, the truths intended to be brought to light, and the records we wish to perpetuate, a confusion of tongues cannot be fairly laid to our charge, but on those who apply language in a sense no longer adapted to the progress of knowledge, nor to Geology as a science, as it now stands, verified by obvious facts which lie on the surface of former events.

Granting that the elevation of an oceanic level, at the instant when stupendous breakwaters had been fabricated at a single blow, exceeded the present level by 3500 feet, we have next to account for its subsidence. Here we learn from what trivial beginnings the bountiful purposes and dispensations of an all-wise Providence have been brought about in probably a short period of time. A few spiral eminences and reefs of granite, far and wide asunder, were probably all the dry land which originally appeared. An immense mass of finely divided clay, however, having the tenacity of bird-lime, amalgamated and attenuated by other finely divided earths, materials which were likely to harden in a short period of time, would mantle around and be brought to a state of repose on the solid base of the primary formation. The oceanic level would consequently subside accordingly as the topmost summits of fresh hills arose above the level of the sea, and became instruments of economy in the construction and suspension of an atmosphere. That atmosphere also would derive its active and buoyant materials from the ocean proportionally as solar rays, otherwise electricity, and tidal action assumed solar courses, a horizontal motion, and acquired a suspending influence. A process so contrived, carrying multiplying powers within itself, would cause a subsidence of the ocean from several incidents combined; such as detritus being driven into embayed water and places of rest; filling vast cavities of the earth, which upheavings and dislocations gave rise to, with water; calcareous and saline matter held in solution, would enter into new combinations and undergo deposition; the material of an atmosphere would acquire a suspensive form; the wants of animal life also and vegetative processes, as well as vast reservoirs of water placed on levels above the ocean. From the vast extent of loose matter driven about in every direction, the second era of the earth's creation and organization was probably terminated in an inconceivably short period of time. We shall assume that under the process just described, at the close of primary deposition, the sea had subsided 1000 feet, or to 2500 feet above its present level.

Nor must other important considerations be overlooked. Perhaps no Geologist denies the existence of powerfully uplifting forces, capable of fracturing the earth's body to the very centre, ere the channels of circulating fluids were formed therein, and established on organic rules. For instance, " every thing proves," says Dr. Bertrand, in his work on the Revolutions of the Globe,* 'that the grand chains of rocks were made by the vertical upheaving of the strata of the primordial soil, before the formation of the soil of sediment; and that this projection carried their summits to a height which the sea has never since reached; and hence these summits consist of bare and salient crests of granite; whilst on the sides, the same granite, which is always undermost, has been successively covered by the matters which the sea has deposited there. These summits, then, must have formed islands." When a general fracture was brought to pass, therefore, coincident with the theory here stated, immense cavities must have been suddenly constructed in the lower regions of the earth's body. This is consistent with every system in being we are intimately acquainted with, as framed by omniscient hands. These cavities would necessarily require some time to fill with water, the more especially when the bed of the great deeps was thickly overspread by silt. In such a juncture, rapid and comprehensive operations must have been in active progress, as concerned the denudation and deposition of the layer of silt here assigned. Then the poles of the earth may not have been altogether determined, at a time when antagonist elements were violently agitated, and tidal action liable to overwhelming disorders, until swung on the North Pole probably by the force of that action. Nevertheless, an upheaving of the granite formation had then fixed the figure of the globe, though temporary and irregular torrents might possibly roll 5000 feet, or 10, or 20,000 feet above the present oceanic level. Elements thus placed in strife so prodigious, were however designed to work themselves into order and harmony, as devised in the purposes and will of infinite wisdom and goodness supreme.

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* Published by Ridgways, Piccadilly.

It would be perfectly consistent in the scheme of an all-wise Power, who rules the universe and moves the very heart of man, to withdraw in some measure an instrument employed in the fabrication of mundane existence, and turn its powers to other uses. We may here limit our train of speculations. Yet on the evidences of organization and almighty wisdom, circulating fluids may be fairly assigned to the bosom of the globe. Proofs of an exceedingly high tidal wave having prevailed during some periods of the earth's construction are still visible, and have undeniably been employed as a mighty instrument in the hands of creative wisdom, though now considerably withdrawn. In the Geology of the British Isles, we shall endeavour to illustrate the general theory here taken, trace the sequence of distinct formations, and frame an order of Geological Science accordingly. While we would disturb the labours of our predecessors in science as little as possible, we would at the same time gratefully acknowledge how much we owe to the labours of the naturalist; trusting that natural philosophy may ere long unravel most of those subtle operations in physics by which so much of the figure of the earth has been obviously determined; and which involves the true merits of the subject matter to be investigated in Geology.

In describing the order in which the Geology of the British Isles has been framed, and brought forth as we now behold it, with the map of Europe before us, the direction of primary currents subsequent to an uplifting of the primary formation arrest our attention in the first place; and the extent, elevation, and bearings of that formation in reference to these currents in the next place. Dr. Bertrand, one of the most popular geologists of France, observes, " the study of the successive strata, and, above all, that of the animals which they contain in a fossil state, proves, with demonstrative evidence, that the sea, after having rested, without doubt, for thousands of ages upon our present lands [we do not admit the necessity of so long a period of time as that here suggested], and having there deposited, during the latter periods of of its sojourn, those masses of shells which much exceed in quantity what would now be found in the entire ocean, at last left exposed a soil fit for the support of terrestrial quadrupeds." If a former tidal wave, not less than 3000 feet above the present level of the sea be therefore granted, the Norwegian chain of mountains must have then had a current along both its north-western and south-eastern sides, by which the vortical current of the Atlantic returned from the Arctic ocean to the equator again. To the eastwards and from north to south, the Ural mountains determined its boundaries. Still further southwards the barriers of central Asia fixed its limits; and on the south-west the Caucasus, the Taurus, the Carpathian chain of mountains, the Alps, and the granite formation in central France up to the Cotentin on Cape de la Hogue, naturally hemmed in and brought the gulf stream northwards again on the 50th degree of north-east latitude, or on the line of the British Channel. Placed under these several limitations, of course the main weight of the returning gulf stream southwards was necessarily on and along the two sides of the Norwegian chain of mountains. Extended as these terms may seem, they are, however, exceedingly plain and obvious, and consistent with the Geology of Europe at large, even in the most exact and limited details.

As the British Isles lie in the immediate channel or channels into which an immense body of water was driven from the northwards, eastwards, and southwards, on the extensive area here pointed out, a description of the primary formation found in those Isles becomes exceedingly interesting. Indeed, this spacious area of water probably extended in a continuous line from Behring's Strait to the Caspian Sea, or more than 4000 miles in length from north to south; whilst the Ural mountains lie upwards of 2000 miles to the eastward of England. Ireland contains three extensive tracts of granite. One in Leinster reaching from Dublin to Kilkenny; a second in Donegal; and a third, separated by the estuary of the Shannon, covers a large portion of the western shore of the kingdom. So that Leinster on the east; Ulster, Connaught, and Munster on the west, are protected and formed into four primary Isles, which have been finally joined together, and now constitute the four provinces of Ireland.

To the north of Scotland, in the Shetland and Orkney Isles, traces and outlines of granite appear, sufficient to rest subsequent depositions upon.

Nor are the Hebrides or the Western Isles deficient in an exhibition of the primary formation.

Scotland may be geologically represented as divided into three distinct primary Isles, originally separated from one another by the Vale of Inverness and Fort William; and that of Edinburgh and Glasgow. In the most northern of these islands, from Cape Wrath to the Isle of Mull, the elevation of granite is extensive. It is in the centre Isle of Scotland, however, from Peterhead on the north-east, to Storness on the south-west, that we meet with the chief granitic barriers, which sheltered the future depositions now so conspicuous in the extent of our island, from John O' Groat's House to the Land's End. From Peterhead to Storness, granite may be regarded the same as perfectly continuous for nearly 200 miles in length, and subsequently strengthened and filled up by primary deposition; while the Isles of Islay and Jura, considered as links of the same chain, may fairly add an additional 40 miles thereto; besides the granite formation of Ireland lying in Ulster, Connaught, and Munster, on the same continuous line, until its extent, from Peterhead in Scotland, to Mizenhead in Ireland, may be estimated at 530 miles in length. This granitic line, however, though it bears somewhat in the direction of Norway, yet does not run exactly in the line of the Norwegian chain of mountains, which bears nearly on London.

The most southern of the Scottish primary Isles, in Kirkcudbrightshire, contains two fields of granite subjacent to each other. The one is about 20 miles in length; and the other 18 miles in length. They are placed almost at right angles to each other. The one bears directly upon the Norwegian chain of mountains; and the other consequently lies transversely to those bearings.

England, like Scotland, has been originally composed of three primary isles, or chiefly so. These are represented by the Cumberland group of mountains, those of Wales, and the counties of Cornwall and Devonshire. For, be it observed, in drawing these outlines, we dismiss Mount Sorrel and Bardonhill, and other trivial patches of primary depositions.

In the west of Cumberland, commencing at Scale Force on the north, and going to Bootle southwards, a line of granite prevails, which extends 18 miles in length, with nearly transverse bearings to those of the Norwegian chain of mountains. Granite is also met with among the Skiddaw cluster of mountains, and is obviously the nucleus on which they rest. It is again met with on Shap Fells.

In the Isle of Anglesey granite appears. But the primary depositions, which abound so extensively in Wales, would scarcely seem attributable to any granite formation observable within the Principality. Being a central position on which and around which several tide-waves held their course, the presence of granite might not be essential to a commencement and continuance of the deposition of drifted silt.

Beginning at Land's End, and proceeding in the direction of the city of Exeter, a line of granite is displayed at intervals which exceeds 100 miles in length, stands over against the district of the Cotentin on the side of France, and Cape de la Hogue. This line of granite nearly bears upon the Norwegian chain of mountains; and is the most southern of the six primary Isles which formed the Geological nucleus of Great Britain.

An uplifted granite formation just described, has therefore been the foundation on and by which primary depositions have been brought to a state of rest. In Ireland four primary Isles are plainly discernible; three in Scotland, and three in England. At the commencement of these extraordinary operations in physics, directed to organic ends, and by which a habitable globe has been framed, much, if not most of the granite here described, must have obviously been hidden beneath the waves of the sea. The cause of order and design so extensively evinced and apparent in the fabrication of the globe, in the instance before us, as well as in others, has arisen out of relative positions, and a train of incidents properly devised. We observe in the first place a pair of oceanic currents working conjunctively, and running apart for a thousand miles along the two sides of the Norwegian chain of mountains, until they rendered that chain a continuous and compact rock, composed first of the primary formation, and next of primary depositions in addition, so as to carry out an omniscient purpose. If such an operation occurred in one instance, a like train in the order of physics and incidents, would lead to similar results. Hence the central ridge of Scotland, lying in a lineal direction with the Ulster, Connaught, and Munster fields of granite in Ireland, would have a corresponding tendency to blend the primary formation and deposits together, and so produce a continuous chain of mountains. But as these did not happen to lie in an exact line with the Norwegian chain and its pair of oceanic currents, the returning gulf stream, disentangled from the labyrinths of those northern, eastern, and southern regions into which it had fallen, now took a prevailing course southwards. A cross current, therefore, occasioned the severance of Ireland from Scotland; and yet the influences and incidents which belonged to the one, were comingled with those which concerned the other.

We have traced a line of granite from Peterhead to Mizenhead. Commencing at Cape Wrath in the north of Scotland, a second line of that formation may be traced to Start Point on the coast of Devonshire. Though not in the direct course of the returning gulf stream, yet it was by no means so much within the influence of transverse currents, as the line of granite between Peterhead and Mizenhead. We here reap a lesson in engineering of inestimable value. But to proceed. While these cross currents obstructed the formation of a mountain chain from Peterhead to Mizenhead, 530 miles in length, or one commencing on Cape Wrath and continuing to Start Point, exceeding 600 miles in length, as produced by lineal currents on the Norwegian chain of mountains, the British Island was formed into six primary Isles, composed of the primary formation and primary deposits; and Ireland into four primary Isles.

Owing to its centrical position, and the uncommon extent and elevation of the granite formation exhibited within its boundaries, the centre Isle of Scotland may be regarded as the pivot those dispensations turned upon, according to which primary deposits took rest upon the primary formation. Along a line from Inverness on the east of Scotland to Fort William on the west, a continuous vale on a low level, exceedingly deep and narrow, and comparatively straight, is met with. These combined incidents go to show that a primeval current had run completely along the entire vale in a south-western course, as far as the western extremity of the Isle of Islay. These waters, however, pressed upon by a still greater weight of oceanic currents, coming either from the north-western shores of Sutherland and Rosshire, or more immediately from the adjacent waters of the Atlantic, were necessarily impelled into the sounds of Jura and

Islay; and then naturally took either an eastern trending on Ulster, Connaught, and Munster, or they fell into the north Irish Channel. Ireland was by such means severed from Scotland; and hence Cantire, sheltered by the presence of granite northwards, is joined to the mainland of Scotland, and carried out to the Mull of Cantire.

In some degree, therefore, the granite formation in the most northern primary Isle of Scotland, as well as in the central one, has been smoothed over and partly filled up by a secondary formation, from detritus driven along by an oceanic current which took a south-western course. Nor is it here unworthy of notice, that the primary deposits on the south-eastern limits of the centre Isle, all but form a right line on the parallel of Aberdeen and Storness, as well as Inverness and Fort William. Again, an intervening space of ground, the vale of Edinburgh and Glasgow, placed between the centre and southern primary Isles of Scotland, is occupied by a plain lying between them, exceeding fifty miles in breadth, containing some lines and patches of the secondary formation, but chiefly composed of still more recent depositions. This spacious and regularly formed vale is at the same time continuous along the centre of Ireland, having Ulster, Connaught, and Munster on its north-western border, with Leinster on its south-eastern one.

The vale of Edinburgh and Glasgow has been formed under incidents somewhat different from those which belong to the vale of Inverness and Fort William. The time required to fill with tidal water the spacious area on the westwards of the Ural mountains, and drawn from the returning gulf stream, during an early period of the earth's fabrication, would allow time enough for a tidal wave to round the north-west of Scotland, and partly meet a tide-wave from the north-east in the vale of Glasgow. To a balance of currents so refined are we to attribute, on the final subsidence of the oceanic level, an eventual joining into one of the four primary Isles of Ireland; and also a complete junction of the six primary Isles of which England and Scotland were originally composed. By most providential means to ends, two fruitful and salubrious islands have been gained from the deeps of the Atlantic Ocean; and the very gulf stream itself, in the impetuous focus of its torrents, converted into an instrument by which they have been fabricated and finished.

As a feature in Geology applicable to the British Islands, the separation of tidal waves thrown off at different points from the returning gulf stream, by the presence of a granite formation, and the meeting again of those waves, deserve the strictest attention, as a future accumulation of deposits would seem to have been a consequence thereof. On the terms already given, the north Irish Channel was unlikely to silt up, and by such means join Ireland to Great Britain, because there is no tidal meeting of opposing currents within that channel, as in the vale of Edinburgh and Glasgow. On the contrary, a tidal current flows through the north Irish Channel, and over a large area of ground in the Irish Sea. Consequently, it is in that sea and on the points of tidal meetings that we are to expect either shallow water or the formation of land. The ordinary soundings between Dundrum Bay and the Isle of Man, are not more than one half the depth of those obtained throughout most of the north Irish Channel. Between Saint Bees Head and the Isle of Man, soundings are still more shallow; and in the Strait of Dover, where the tide-wave of the North Sea and the British Channel meet, the highest soundings obtained are but shallow.

As the primary Isle on the centre section of Scotland divided the returning gulf stream northwards, and admitted a rejunction thereof in the vale of Edinburgh and Glasgow, and still further southwards; so the primary Isle which holds so prominent a feature in the Geology of the south of Scotland affords numerous instances of summit passes, which have obviously been the meeting ground of opposing tide-waves. A hause or focus of parting summits is found between the valley of the Tweed and that of the Clyde; the Yarrow and the Annan; the Nith and the Ayr; and the Cree and the Doon. These need be named only to show how distinctly a meeting of antagonist tide-waves have caused a large extent of primary deposition on the south of Scotland. Mapped out geologically as they are, and resting as they do upon the peculiar position of the granite formation, an unbroken chain is preserved from Saint Abb's Head on the east, to Port Patrick on the west, a space of 140 miles in length, and holding a mean breadth of about 35 miles.

The primary Isle on the south of Scotland, so conspicuous in the Geology of our island, may be regarded as a base on which the depositions of England rest, working in combination with other surrounding incidents, as well as those within itself. The formation of the Cumberland group of mountains is obvious. Fortified by a granitic barrier of 18 miles in length on the west, the Skiddaw field of granite on the north, and still further sheltered northwards by the south of Scotland, its position and defences were admirably adapted for gathering drifted silt from an eastern tide-wave by the North Sea; a northern tide-wave through the north Irish Channel, and a southern one by the south Irish Channel. This group of mountains, therefore, as decided by granitic barriers within itself, which determined and fixed the deposition of tidal drift, is situated upon the precise ground where a northern, an eastern, and a southern tide-wave must have all terminated in an early period of the earth's construction, and driven tidal detritus to places of rest.

Strictly examined on the spot, the features of this primary Isle confirm the deductions to which we have come. Taking our stand upon Raise Gap, a pass out of Cumberland into Westmoreland and North Lancashire, a summit deposit in the meeting of a northern and a southern tide-wave is not only evinced, but all the chief lakes of the district are found bearing upon Raise Gap as if it were a common centre. So it truly is. On this point a northern, an eastern, and a southern tide-wave terminated. Nor is this all. The figure of the lakes resemble each other, as if they had winded their way in the direction of a tidal wave. Is all this concordance of incidents and figures to be attributed to chance, and the outpourings of igneous fusion, or to oceanic currents from every point of the compass; for the north Irish Channel takes both a western and a northern course, terminating upon this group of mountains as upon a common centre? Whether we consider existing courses of tidal currents, the relative position of the primary Isle under our review, or the evidences of oceanic currents in a past age of the world, each and all such tests and proofs go to confirm a Neptunian origin of these mountains, and deny an extended interference from Vulcanian fusion.

On the north-west side of this mountain group, near to Bassenthwaite Hause, a summit pass from the river Derwent to the Ellen is met with; in the vale of Keswick and Penrith, passes to the Derwent, the Caldew, and the Eamount are found; at Buttermere Hause, the valley of Crummock Water on the west, opens into the vale of Newlands on the east; the Hause of Honister Crag, is a pass out of the vale of Borrowdale, to the lake of Buttermere; Eskdale Hause also leads out of Borrowdale into Eskdale; and Styhead from Borrowdale into Wasdale. Kirkstone is a pass between the lakes of Ulswater and Windermere; and Nan Bield leads from Kentmere into Mardale. In truth, these striking instances of tidal meetings, and obvious junction summits having been the result, might be multiplied in detail, until the most trivial vallies in Cumberland, Westmoreland, and North Lancashire were enumerated. Features so general and obvious need be noticed only to carry conviction to the mind of every dispassionate and observing person in confirmation of the Geological theory here given.

The tide-wave of the north Irish Channel still takes it course on the northern and western shores of Cumberland, and bearing on the courses of its various rivers. That of the south Irish Channel bears directly upon the rivers, passes, and channels which present themselves southwards; and to the eastwards of this primary Isle, Geologists admit the prevalence of more recent formations. The tide-wave of the North Sea, therefore, must have formerly held a course which contributed largely to the material which compose the Cumberland group of mountains, as we find the granitic formation in the west of Cumberland placed in the very face of its natural range. Besides, the various points of meetings on which these tidal currents bore, is the exact ground which the Cumberland group of mountains occupy, resting on a granitic base which checked an eastern tide-wave, and determined the precise operations of those on the north, and from the south.

The primary Isle of which Wales is mainly composed, would seem formed of the secondary formation, or primary deposits. Were a curved line drawn from Saint Abb's Head on the north-east, to Cape Clear on the south-west, such a line might be made to touch upon the eastern borders of the Cumberland group of mountains, on the eastern edge of the granite formation in the Isle of Anglesey, and on Carnsore Point. Hence we observe five different points of land, which contributed to fix the range of tidal action, render the granite of the Isle of Anglesey a point to rest upon, and so commence the work of tidal deposition in a series of curved lines. Such are the sort of lines in which the mountains of Wales lie; and proportionally as tidal currents were separated from each other by progressive depositions, a tendency to gather still more might augment, until at a future date those deposits extended from the Isle of Anglesey to the Strait of Dover, and by a subsidence of the ocean emerged from the great deeps. Wales, indeed, at the period of time we are here treating upon, must have occupied a space of water sheltered northwards and southwards, eastwards and westwards; while the curved figure of Caernarvonshire and Cardigan Bay correspond to curved lines resting on Carnsore Point, Cape Clear, and Berwick-upon-Tweed, or Saint Abb's Head. Not to say that the general trending of the Welsh mountains, as well as much of the south-east section of England, conform to the theory of deposition here adopted.

The relative position of the primary Isle of Cornwall and Devonshire, would more especially contribute to press currents on the south-east of Wales, into a set of curved channels, as we shall further illustrate in treating on more recent formations. Within the limits of this primary Isle, however, the influence of tidal action on primary depositions is very plain. Lying on almost the direct course of the returning gulf stream from the north-east of Europe; and met, on a corresponding course, by an opposing tide-wave from the south Irish Channel, the patch of granite which fortifies the Land's End, like the point of a pile shod with iron, is the beginning of a process similar to that by which the great Norwegian chain of mountains has been perfected. Certainly on a much smaller scale, and a diminished elevation. The features of the Cornish and Devon primary Isle, at the same time show that the prevailing current and course of deposition has been from the westwards, conformable to what is yet the case, a meeting of the east and west tide-waves in the Strait of Dover. Agreeable to such conclusion, the field of granite in Devonshire, or that which lies most eastwards, on a line of 100 miles from the Land's End, is much more extensively mantled around by primary depositions than any portion of this granitic chain to the westwards. On this important ground, nothing could more distinctly prove, in the period of primary deposition, the set and meetings of an eastern and a western tide-wave; and show the prevailing influence of a western tidal current, coming directly from the Atlantic Ocean, on the formation of England and Wales. It is obvious that the tide-wave of the North Sea has at no time run to the westwards, so far as either the Irish Sea, the Bristol Channel, or the British Channel. Hence drift could never make its way from the North Sea to the Atlantic Ocean; and deposition followed as a matter of course, whether on the escarpments of the Ural, the steppes of the Caspian Sea, the plains of eastern Europe, or on the shores of England. In this fact we discover a key to European Geology.

The six primary Isles of which our Island has been originally composed, afforded the nuclei on which subsequent depositions have rested. Were a line drawn from Peterhead, in Scotland, to

Taunton, in Somersetshire, we should find such line touch slightly on the eastern extremities of each of the five Isles met with in a space which extends 445 miles from north to south. But little granite is found either on or near this line; and we may therefore attribute a chain of conformity so remarkable, to all but uniform meetings and courses by the tide-waves of an east and a west sea. While currents from the westwards ran eastwards nearly as far as the eastern extremities of the primary Isles, it is probable that the tide-wave of the North Sea in a southwards course swept off the talus of those Isles, set bounds to their extension eastwards, and determined their limits on a common line. As we deny chance in combination with order and form, the uniformity here observed must be viewed as a result of tidal action, more especially as the leading outlines of that action yet remain the same.

While primary deposition was still in progress, sufficient proofs yet exist to sanction an inference that either a constant or a temporary tide-wave had risen as much as 3,500 feet above the present level of the sea. Undeniable evidences thereof seem to remain, in whatever way or by whatever mode this mighty instrument of creative power may have been disposed of at a future date. At the conclusion of the first period in which the earth began to take an organic figure, a considerable subsidence of the ocean had been obviously brought about, when its constant or temporary altitude may be then assumed at 2500 feet above the present level, or a subsidence of 1000 feet. At this altitude of the sea, the Cornish and Devon primary Isle must have been but a rock concealed beneath the waves of the ocean; yet at the same time exercising powerful influence in the fabrication of a future island—fair in features, fruitful in soil, and salubrious in climate.

At the conclusion of the secondary formation and the beginning of the tertiary, when the main portion of finely divided aluminous and silicious materials had undergone deposition, some of the crystalline and rougher grains of these and other earths which still remained in a shifting state, must have had a tendency to deposition. Greywacke may be nevertheless assigned to the secondary formation or primary deposits. The tertiary formation may therefore commence with old red sandstone, and embrace the entire series of crystalline earths up to new red sandstone. It therefore includes carboniferous limestone, limestone shale, millstone grit, the coal measures, and magnesian limestone.

Old red sandstone, probably composed of rougher grains than the chief materials of the secondary formation, and having a less tendency to float upwards, naturally went in large quantities to fill up vast spaces and cavities on a low level, which lay among and between the primary Isles of Great Britain. An immense extent of its strata may therefore lie concealed beneath more recent groups of depositions; and in thus treating the classifications of Geology, old red sandstone must be considered a more early group than carboniferous limestone, and the implied base on which much of the tertiary series rests. But on the terms here laid down we neither find, nor can expect to find, any regular sequence of strata in succession to each other. That plainly depended upon the incidents by which deposition was accompanied. It is the priority and order of different groups, therefore, divested of a regular succession of strata, to which we must look in Geological enquiries. The presence of any one group by no means determines those which may be expected beneath or above it; the priority of the one, or the posterior formation of the other, is alone settled. The older lie beneath, and the newer above.

The extensive area and considerable elevation of old red sandstone, mantled around the south-eastern edge of the Welsh primary Isle, give place to some interesting evidences in Geological speculation. Why does this group there abound to an extent so unusual, and on so considerable an elevation? It shows in the first place that a high tidal wave had continued until then, though a considerable subsidence of that wave had been brought to pass. It shows in the next place that a subsidence in the oceanic level had hastened deposition on this peculiar point; and that the tide-wave of the North Sea, on its departure southwards from Peterhead, by Saint Abb's Head and Berwick-on-Tweed, had an augmented tendency to take a south-eastern direction, and less inclination to run in a south-western one than previously. The tide-wave of the south Irish Channel also, had plainly begun to incline less to the north-east, and more towards the south-east. Thus at an early period, whilst these opposing tide-waves met upon the granite of Anglesey along courses slightly curved, the point of meeting had now begun to assume angular bearings.

In the vale of Edinburgh and Glasgow, old red sandstone is observed skirting both its sides somewhat extensively; and in the valley of the Tweed, which forms a vacant space in the south primary Isle of Scotland, it has evened and filled up the ground. At Dunstanborough in Northumberland, an out-crop of old red sandstone commences in a south-western direction, which, for thirty miles in length, bears upon the centre of the Cumberland primary Isle, and on the parallel of the south Isle of Scotland, as if projected forwards by a tide-wave from the North Sea, until it suddenly bends and takes a westerly direction to the tidal pass and meeting of Glenwhelt, running westwards as far as Castle Carrock in Cumberland. Here it takes a south-eastern course, as if limited by the tide-wave of the Solway Frith, and giving a future base to Croglin Fell, Hartside, and Cross Fell. Thus, the process by which these tidal meetings at a future date filled those various spaces up, which lie between each neighbouring primary Isle, is so far distinctly illustrated.

It must in many instances be admitted, however, that the age of red sandstone may be exceedingly questionable; not to say that sandstone closes the secondary formation in greywacke, is mingled throughout the tertiary formation, and closes it with new red sandstone. Probably, that which may be justly denominated old red sandstone, and lies at the base of the tertiary formation, was speedily deposited on the close of the secondary formation, or even partly before its final close. So classed, old red sandstone never overlies carboniferous limestone, as it is a deposit which belongs to a more early date. But it does not at the same time follow that the former is always overlaid by the latter. When red sandstone, therefore, rests upon the secondary formation, and is not overlaid by any newer formation at all, a test of its age being defective, it may become difficult to assign it a distinct place in Geological classification; and this not unfrequently happens.

On the close of the deposition of old red sandstone, the Geology of our Island assumes a more extended and formal shape in our hands. Its connecting links are less dislocated, the range of the various tide-waves become distinctly mapped out, the primary Isles stand apart from the rest, and the processes on which creation's round has been organically conducted, become in themselves unanswerably authenticated. All fears on the general correctness of our theory cease, its evidences are many and obvious, a protracted period of time is not asked for, Omniscience is vindicated, and neither vague nor inconsistent arguments are resorted to.

We next come to a consideration of mountain or carboniferous limestone. Here we confess that its origin is beset with incidents not easily explained. Alumine and silica, the chief materials we have been previously treating about, are in themselves simple earths, and combinable in any proportions. Again, why has the deposition of carboniferous limestone been so much delayed, and hitherto so sparingly combined with aluminous and silicious materials? Decomposition and an exhibition of new forms and combinations are the chief modes and means by which a habitable globe has been constructed. Proper organic changes constitute a general law in physics, and a means by which better and safer ends are devised; whilst Infinite wisdom ever works according to omniscient forms. Might not lime up to a given date be mainly held in aqueous solution, and owe its origin in a carboniferous form to carbonic acid drawn from atmospherial regions, by going through processes of vegetable and animal life ere it fully combined with lime? Even grant this suggestion to be an idle theory, yet its statement is sufficient to show that what might be so mysterious to us, might be easy and plain in the hands of an allwise and almighty Creator. If lime originally took a fluid form, and carbon an aerial one, might not their combination lead to a material subsidence of the ocean? As carbonic acid might give place to oxygen and hydrogen, elements of the ocean; whilst the material of lime was converted from a fluid to a solid form. Enough is perhaps here said to show the sort of means employed in the hands of creative wisdom, and the effective and speedy forms on which its operations have been conducted.

The enormous quantities of calcareous earth, whatever its origin may have been, which subsequent to a given period of time has been scoured from the Arctic Ocean, and distributed so plenteously on the borders of European levels, is exceedingly apparent. On the fact we take our stand. Previous to the deposition of carboniferous limestone, the Penine chain of England had little or no existence, except a foundation of old red sandstone to rest upon. This chain, so conspicuous in the Geology and features of England, may be said to commence at Berwick-upon-Tweed, and terminate at Ashbourne in Derbyshire. Though such line probably remained broken in the outset, yet a progressive course of deposits, composed of mountain limestone, limestone shale, and millstone grit, obviously filled up previous vacancies, like the secondary formation on a primary one along the Norwegian chain of mountains, and perfected the English Penine chain of hills as they now stand, on a base prepared and composed of old red sandstone.

Most of the material of the Penine chain, and in which carboniferous limestone predominates, has probably been brought by the tide-wave of the North Sea from within the Arctic circle, the more especially as it commences at Berwick-upon-Tweed, rests upon the secondary formation at that place, and proceeds southwards from thence to its terminus in Derbyshire. From Berwick to Glenwhelt, which favours the view just taken exceedingly, the mountain limestone chiefly lies in an area enclosed by the primary Isle of the south of Scotland on the north-west, and by the Dunstanborough ridge of old red sandstone on the south-east, as if it had got into a funnel which carried it within the vortex of a western tide-wave in the Solway Frith. What is still more remarkable, a narrow strip of carboniferous limestone may be said to skirt the south-eastern and southern borders of the old red sandstone from Dunstanborough to the tidal pass of Glenwhelt. To the north-west of this pass, on a line of twenty miles, the limestone is suddenly cut short, as if swept away by the tide-wave of the Solway; and at Castle Carrock the line of deposition takes a south-eastern direction for some distance, until it falls into the general range of the Penine chain southwards.

The Skiddaw cluster of mountains, standing out northwards on the centre of the Cumberland group, take the shape of a convex curve on their northern aspect; and we observe the carboniferous limestone mantling directly along such curve in a belt-like form, from Whitehaven to Ravenstonedale in Westmoreland, preserving a continuous line for 65 miles in length, until it finally joins the main body of the Penine chain of hills. In the tidal meeting and pass of Glenwhelt, through which the Newcastle and Carlisle railway goes, the carboniferous limestone has been scoured off. But immediately on the close of this pass a high range of that group of deposits sets in, which runs continuously southwards as far as Burnley in Lancashire; and it would seem that the tide-waves of both the north and the south Irish Channels had run up to the several tidal meetings formed in the Penine chain of hills, by the North and Irish seas.

To this balance and meeting in opposite tidal currents, and operations originating therein, are we to attribute the direction and features of the Penine chain of English mountains, which extends from Berwick-upon-Tweed, southwards, to Ashbourne in Derbyshire, a distance of 195 miles. It is on this line, therefore, that we are to look for transverse passes, on which opposing tidal currents have met between the eastern and western shores of England. All newer depositions must at the same time be considered as subject to those terms, which the continuous formation of the Penine chain had settled.

As tidal intercommunication has obviously existed across the kingdom from the east and the west, it cannot be ascertained in what direction tidal drift has originally come; but we may be able to attribute the final work of deposition to one or another of the various tide-waves concerned. Accordingly, the field of carboniferous limestone in Flintshire, and the one which lies in the basin of South Wales are obviously the production of tide-waves flowing from the south Irish Channel. To the southwards of Ashbourne a complete denudation of carboniferous limestone and its accompaniments has taken place, until we find it commonly resting on old red sandstone in Monmouthshire and South Wales, and occupying a few detached patches of ground in Gloucestershire and Somersetshire.

We have next to consider the deposition of the coal measures; what the origin of coal has been; in what direction it has been brought, and why it is found so abundantly in one place, sparingly in another, and altogether wanting in others.

Had the material of which coal is composed not been mainly a deposit, and a foreign product, it might not have been so evenly found in its accompanying strata, as its position and other incidents would seem to indicate. Its combustible properties may be fairly attributed to a vegetable origin. So much granted, from whence is the abundance of bituminous ingredients usually found in carboniferous coal derived? Pine is distinguished from any or most other ligneous products for the bitumen it contains. We shall, therefore, attribute the material of coal, and the black appearance it exhibits, to ravaged forests of pine, which, under a high superincumbent pressure, have undergone a low state of combustion. Hence, a black, brittle breakage, and charred appearance, in which the organic traces of its origin are no longer distinguishable, have been assumed; while its combustible properties have been preserved quite free from decay, and admirably fitted for our use. In none of these respects do the phenomena attendant on coal appear at variance with immense rafts of drifted forests of pine, which have undergone deposition, and mechanical and chemical action. The very fact of coal being still liable to spontaneous combustion favours the conclusion to which we have come.

Previous to the period of time, however, in which a deposition of coal commenced, a further subsidence of the oceanic level would appear to have taken place. Probably to the extent of an additional 1000 feet; estimating the tidal level at 1500 feet above its present elevation. In case this high level were temporary only, and which seems very probable, a larger extent of land might be offered to the growth of pine forests. An exact consideration of oceanic currents at the same time shows how exceedingly favourable they have been for stranding the drifted forests of foreign climes upon British shores.

The South Pole may be viewed as a tidal centre, from which, like muscular pulsation in animated nature, the various tide-waves of the globe take their start. The configuration of the earth, in conjunction with its equatorial motion, renders this a physical consequence. In the first place, a tide-wave runs northwards upon Cape Horn, and from thence along the eastern shore of the Pacific Ocean as far as Behring's Strait and Cape Lopatka, returning southwards again on the western shore of that great ocean; it then traverses the Indian Ocean also, north and south, until it reaches the Cape of Good Hope. Here it turns northwards again, and makes it way to the Arctic Ocean; turns there, and flows southwards along the Norwegian chain of mountains, beyond which all drift was embayed among currents and counter-currents, and stranded as a natural result Vegetable drift, therefore, from almost every clime on the face of the globe, might be finally stranded on British shores. Limiting the ground, however, on which most of the pine grew, which provided coal for Great Britain, to forests ravaged from the Norwegian chain of mountains, we may be thus able to account for a supply of the material of coal in ample abundance. Norway is yet a clime on which pine prospers. It may have been exceedingly more so at a former date; and a periodical succession of devastating torrents may have despoiled it of thick and lofty forests, and swept them on the great deeps, to be embayed, stranded, and deposited on the extensive zone of the European coal line.

Many incidents may besides have occurred to which no satisfactory answers can be now given. Wonderful sequence of changes in the processes and provisions of creation may have been brought to pass. For aught we know to the contrary, the present poles of the earth may have been on the equator. Great variations and disorders have unquestionably happened, which we have at this day no means of ascertaining, though we have abundant evidences to show that stupendous changes have transpired in the various ages of creation. Amidst the decomposition of gases and fluids, and new combinations formed, periods of rapid and almost spontaneous vegetation might happen, to be succeeded by destructive torrents for a season, followed by fruitful repose. It is not, therefore, a forced conclusion to say, that the despoiled forests of a past period of time have furnished the material of coal; whilst chemical analysis would pronounce coal to be decomposed and preserved forests of pine, prepared for combustion at a future day.

It has been already explained with what certainty oceanic currents yet existing were qualified to bring drifted forests on the eastern shores of our island, and how admirably formed that ground has been for embaying, stranding, and retaining the material of which coal is composed. Nor is it an unfair deduction to say that tidal currents flowing in the direction of such spaces of water as are suited for the embaying, stranding, and deposition of drifted forests, should in some measure produce a uniformity in results. Hence a repetition of seams of coal upon the same ground, though variable in thickness and quality.

While few or no vegetable or ligneous impressions are discoverable in the coal itself, yet the beds immediately accompanying it are remarkable for the most distinct traces of organic remains. It may be assumed that each bed of coal has originally been a raft of drift-wood, embayed, stranded, and sunk on a shore of the sea. Such shore would be more or less shelving as incidents might determine. One of these rafts of drift-wood might continue afloat for years; and accumulate in thickness and extent, form a sort of floating island over-spread with aquatic plants, the seeds and roots of which had come along with the drift on which they took root, sprung up, and sometimes grew vigorously; not only augmenting the mass of combustible materials considerably, but also leaving those vegetable impressions and remains which occur so frequently and abundantly in the accompaniments of coal. Nor would it be surprising to often find plants still preserving an erect position, especially in or above the thickest seams of coal.

In time an accumulation and pressure of superincumbent earth must have weighed down and sunk these rafts of drift-wood, and placed them upon a substratum which had its dip seawards. Hence neither the broken features of a field of coal, nor its being placed on considerable and varying inclinations, not even its perforation by the underlying limestone or other stray beds, would prove a future disturbance by uplifting powers emanating from the bowels of the earth. Nor would their position deny the interposition of such internal force, as similar irregularities might occur by either the interference of physical force, or a submerged raft alighting upon an irregular base.

On the train of evidences here detailed, as well as those intended to follow, the chief material of coal must be considered as ligneous in origin, that it is a foreign product, derived from ravaged forests overthrown by periodical torrents, and swept into oceanic currents, which eventually floated them on the coasts of our Island, and other localities on the Continent of Europe; and why coal is found abundantly in one place, sparingly in another, and wanting altogether in other places, has depended upon ground producing and yielding up forests to the ravages of torrents and the ocean, the direction of tidal currents into which those forests have been precipitated, embayed, stranded, and eventually sunk by an accumulation of silt and other attendant incidents.

According to what has been said before, where shall we expect to find coal in England and Wales? Immediately on, or near, or in connexion with antecedent formations between Berwick-upon-Tweed and Milford in Wales. As the deposition of the Penine chain of hills in England, depended on the meetings of eastern and western tide-waves, though the outline of a continuous ridge were generally preserved between Berwick-upon-Tweed and Ashbourne in Derbyshire, yet its outer edges were in many parts of the chain exceedingly uneven, and covered occasionally by indented bays. The out-crop of the Dunstanborough old red sandstone, having reached Castle Carrock in Cumberland in a waving line as previously described, is again seen to the eastwards at Middleton in Teesdale; and from Castle Carrock carboniferous limestone, limestone shale, and millstone grit run in a south-eastern direction as far as Croft in Yorkshire. In the next place the coal measures run westwards from South Shields, through the tidal hause of Glenwhelt to Castle Carrock in Cumberland, on a line which extends 50 miles in length; while Croft is more than 70 miles from Dunstanborough.

As the main line of coal in Europe, which commences in the north of Scotland, and terminates on the northern limits of the Carpathian mountains, takes the figure of a parabolic curve, in a girdle-like outline, to the extent of 2000 miles in length, and on the concave centre of which the Norwegian chain of mountains hold their south-western bearings, we may conclude that the tidal courses of drift-wood either lay along or from the two sides of this extended mountain chain. Hence Berwick-upon-Tweed and Dunstanborough were precisely points of land on which tidal drift wood bore. No figure of antecedent formations, combined with evidences of tidal currents, the traces of which yet remain, could have been more skilfully devised for embaying, stranding, and submerging the drift-wood of northern regions, than the angular positions which Dunstanborough, Glenwhelt, and Croft present, as the set of the tide-wave must have then been from Dunstanborough to Croft, leaving this spacious area, of which the river Tyne is now a central inland drain, a piece of embayed water into which drift would be naturally drawn by tidal operations through the hause of Glenwhelt; the very sort of result to which the origin of the Goodwin Sands and Romney Marsh, with the Strait of Dover between them, may be rightly attributed. In the deeply indented bay here described, we accordingly meet with a deposition of the coal measures, and the greatest abundance of coal also, up to the fullest limits thereof. Suppose that, at this early date, along the Norwegian chain of mountains, an average breadth of 100 miles of dry land were covered with lofty forests of pine, had these been suddenly swept off by a torrent, much of this amazing supply of the material of coal must have been carried on Berwick-upon-Tweed and Dunstanborough. Moreover, at a date when Dunstanborough was upon the shore of the North Sea, and an indented bay obtained 50 miles to the eastwards of Tynemouth, we now find the whole of such a bay silted up, and containing an abundance of coal throughout, while Dunstanborough is yet on the shore of the North Sea. An inference so obvious cannot be denied. It need not be even named in this place.

A vast supply of the material of coal having been drifted into the tidal meeting of Glenwhelt, it would seem that a part thereof had been floated into the tide-wave of the Solway Frith, then carried westwards by a reflux tide, had gone to form a coal-field in Cumberland, which commences at the water-shed on Saint Bees Head, and mantles around the carboniferous girdle previously described, eastwards, to Castle Sowerby, on a line curved northwards, exceeding 40 miles in length. The influence of tidal action in embaying and stranding the material of coal, is too apparent and interesting to be passed over unnoticed. The northern border of the Cumberland primary Isle, as previously shown, forms a convex curve northwards; while the Scottish coast on the opposite shore of the Solway naturally took a concave curve southwards. Hence the tide-wave of the Solway from the earliest periods of the earth's fabrication, pressed upon the north shore, and eased its south shore. Deposits have therefore accumulated upon its south shore in regular order; while the north shore has advanced very little, and on that little the ground is broken and irregular. In perfect concordance with tidal action, all the material of coal is found on the southern shore of the Solway in an exact zone; while its northern and eastern borders are all but denuded from Kirkcudbright to Kirkby Stephen, along a concave curve or bight nearly 100 miles long. Proving that carboniferous limestone is not necessarily a base on which coal is always found. For it precedes the deposition of coal only, and often occupies those spaces in which the material of coal might have been otherwise embayed and stranded.

In the formation of the coal-field in Cumberland, an ebb tide having carried out drift-wood to the water-shed on Saint Bees Head, the true line of stranding is from west to east. Coal is the most abundant, the best, and most regular at Whitehaven, in the immediate neighbourhood of this headland and water-shed. And why does coal cease altogether at the water-shed? Because no drift-wood could make its way beyond it. A reflux tide from the south would carry it north-westwards; and a flux tide from Saint Bees Head northwards, would cause it to strand. As a general rule, therefore, applicable to the Cumberland field of coal, the beds are fewer, thinner, and worse in quality the more distant they are from Whitehaven, or the tidal water-shed on Saint Bees Head. Why does this headland stand out seawards so much? Why does it exhibit so bold a section as it does of new red sandstone? Why is the Irish Sea so shallow between that and the Isle of Man, where it is most narrow? Why does carboniferous limestone stop here? Why is it the southern terminus of the coalfield in Cumberland? Are these several incidents to be considered as combinations originating in chance? or are they to be taken as regular and invariable operations of tidal action? Negative answers are inadmissible. Affirmative ones are obvious; and show that the material of coal is chiefly a drifted and foreign product.

In the circuit of the Solway basin, carboniferous limestone bears coal on 45 miles in length only; while 95 miles of such limestone either bears that fossil very sparingly, or is altogether wanting; and 30 miles, from Kirkcudbright Bay to Ruthwell, is denuded of mountain limestone also, as well as from Saint Bees to the estuary of the Duddon, which is 25 miles more. On that section of the shores of Cumberland, new red sandstone even rests upon the primary and secondary formations. Proving very distinctly that, in the same basin, given series of deposits do not necessarily rest upon and succeed each other. Oceanic subsidence and other incidents being liable to arrest any given sequence of depositions. Not to say that an occasional uplifting of previous strata may have varied the courses of tidal currents and tidal action.

Starting at Croft in the north of Yorkshire, and drawing a line southwards on the eastern side of the Penine chain, to the river Wharfe, 40 miles in length, the main field of coal is found wanting; while most of the vales inclosed within the range of the Penine chain have coal. The cause of these distinctions are obvious. In this space previous deposits of limestone, shale, and millstone grit, are found as much to the eastwards as the range of Dunstanborough and Croft is found to lie. Consequently, a tidal current bearing drift-wood, and abutting strongly on previous formations, denuded its eastern line of coal, except where westward openings embayed and stranded drift. There coal is found, and no where else, as at Leyburne and a few other places.

No sooner do we observe an extensive prevalence of carboniferous limestone, cut short on the south of Clitheroe, Colne, Bradford, and Harewood, leaving embayed spaces for driftwood to strand in and submerge, then the great Yorkshire and Lancashire coal-fields commence on both sides of the Penine chain. In this instance affording an established fact that where there is the least carboniferous limestone there is the most coal, and the least coal where lime prevails the most; and yet previous deposits of lime, shale, and millstone grit have afforded shelter to the stranding of drift-wood in those embayed spaces which intervened along the range of the Penine chain. For 35 miles south from Colne, mountain limestone and millstone grit occupy a comparatively limited tract of ground; and it is where such limitations occur that the main body of the Yorkshire and Lancashire coal-fields are found.

On a line drawn in an eastern and western direction, passing through Barnsley and Wigan, the measures bearing coal exceed 70 miles in length. To the southwards of Colne, and up to the limestone group in Derbyshire, an area is occupied by coal in Yorkshire and Lancashire, which may be estimated at 40 miles square. But for 55 miles to the northwards of Colne, coal is almost entirely wanting; and a broad range of mountain limestone and millstone grit are found to prevail, proving the justness of what has been said before. But another feature belonging to limestone and coal in this section of the kingdom is, both the Yorkshire and Lancashire fields of coal go continuously into Nottinghamshire and Staffordshire, until carboniferous limestone and the coal measures are entirely cut off at once and together, by transverse tide-waves which have rounded the northern borders of Wales, communicated with the Bristol Channel southwards, and with the valley of the Trent also in a north-eastern direction.

The various incidents and evidences, which belong to carboniferous limestone, shale, and millstone grit, together with the coal measures, and lying between Berwick-upon-Tweed and Ashbourne, would seem to favour a conclusion that the chief supply of material of which these different groups are composed, have been drifted by tidal currents on Berwick-upon-Tweed and Dunstanborough from or in the direction of the Norwegian chain of mountains. The extensive area occupied by carboniferous limestone and the coal measures in Flintshire, would appear to be prolongations of those deposits from Nottinghamshire and Derbyshire. Whenever the tide-wave of the North Sea drove limestone to the southwards of Ashbourne, or driftwood beyond Nottingham, the small primary Isle of Mount Sorrel and Bardon Hill, coming in the way, naturally caused the talus of these groups to be swept off, and carried into an ebb tide from the Irish Sea, then undergoing deposition either in Lancashire or Flintshire by a flux tide; or a like process, by a reflux and a flux tide, might supply the various groups of lime and coal that lie in south-western directions—such as the Ashby-de-la-Zouch, the Warwickshire, South Stafford, or Dudley, Forest of Dean, Gloucester and Somerset, and the great South Wales coal-fields.

A piece of ground so strong as the small primary Isle of Mount Sorrel and Bardon Hill, producing a powerful scour around it, must have exercised a powerful influence in deciding deposition and denudation in that section of the kingdom. It in the first place probably facilitated the deposition of lime in Derbyshire and coal in Nottinghamshire, until it finally cut them short altogether. For this Isle lies 10 miles south only of the Nottingham coal-field; and about 15 miles distant from the southern point of the limestone group in Derbyshire; while the coal-field of Ashby-de-la-Zouch lies sheltered on the north-west border of this primary ground.

An appeal to the several incidents and facts in which these questions are involved, would seem to show that most of the material of coal in England and Wales has been brought by a tertiary tide-wave coming from the returning gulf-stream on Berwick and Dunstanborough; and from thence distributed along a southern line of deposition, which affords so many critical and interesting incidents for investigation to dwell upon. Placed as the several coal-fields of England and Wales are, either along a common line, or within the vortex of tide-waves, which worked in communication with each other, in whatever direction drift-wood might be carried, it was almost certain when once upon our coasts to be embayed and stranded on some bight of land or other. Every tide-wave into which it could fall formed some link of a tidal vortex holding its terminus and tendency to a deposition of drift upon some locality or other in England or Wales.

The next group of depositions where met with, in succession to the coal measures, is usually magnesian limestone. Projected southwards in a line bearing on Dunstanborough, it commences immediately on the south of the river Tyne, and takes an almost direct and continuous course as far as the river Trent, superinduced on the eastern borders of the Durham, Yorkshire, and Nottinghamshire coal-fields; and also along most of the space of ground between Croft and Harewood, on which coal has been very sparingly discovered. Near to Nottingham it is cut short the same as the coal measures; and a portion thereof would seem to have been carried forwards, by the route already assigned to the coal of South Lancashire, and placed on an eastern and western line, between Manchester and Great Sankey, along the southern borders of the coal measures. Hence those Geological lines, which, to the south of Berwick-upon-Tweed, are in the early formations so dislocated and waving, as far as Nottingham, in the magnesian limestone group, become all but direct and continuous.

It may be observed in this place that, between Croft and Harewood, it is hardly probable that, as some Geologists have suggested, much coal is overlaid by more recent deposits. In that interval, magnesian limestone even is either more sparingly exhibited or not met with at all, than on ground where it overlies the coal measures. Nor is it probable that much coal, in the economical dispensations of Providence working on omniscient principles, lies buried at an uncomeatable depth to man, or that it is extended any considerable distance seawards. The various successions of stranded drift-wood could seldom g[illegible] far out seawards, ere it became overlaid by silt, covered with aquatic plants, broken up into fragments, and sunk.

New red sandstone may appropriately close the tertiary formation, or the sandstone series in stratified beds, along with its occasional accompaniments of limestone and coal. On the eastern side of the kingdom, red sandstone commences at Hartlepool on the north, in succession to magnesian limestone, and occupies an average breadth of of about 10 miles along the valley of the river Tees, up to Croft in Yorkshire, on an estimate of 20 miles in length. So far the Tees is its central inland drain. From Croft it runs along the eastern range of the magnesian limestone group to Nottingham, in an almost direct and broad track, about 108 miles in length, on an average breadth of 10 or 12 miles, being drained at intervals by the Swale and the Ouse, until it has crossed the Humber. Then it occupies the valley of the Trent to Nottingham. Nothing can so far be more exactly agreeable to tidal deposition by a current from the northwards, bearing on Peterhead, Saint Abb's Head, Berwick-upon-Tweed, Dunstanborough, and Hartlepool, which has probably been a former outlet to the valley of the Tees.

At Nottingham the red sandstone group is suddenly contracted to about four miles in breadth, and its previous trending southwards in a line stops.

There it commences to the westwards, cutting off or overlaying for 50 miles in almost a direct line all the southern extremities of the older groups of the tertiary formation. Upon this eastern and western base resting immediately southwards, an area equal to 50 miles square is occupied by an outline of the red sandstone group of deposits. Within this area, the primary Isle of Mount Sorrel and Bardon Hill, and the coal-fields of Ashby, Warwickshire, and Dudley, are found. The river Trent here forms a vast drain across the entire northern section of the red sandstone district; and this river may be said to cut wholly off the talus of the Penine chain, bisecting the kingdom as it does between Newcastle-under-Line and Nottingham.

On the westward of Newcastle-under-Line, the red sandstone takes a sudden bend northwards to Manchester, and extends about 58 miles southwards to Shrewsbury, on an average breadth of about 35 miles; and also occupying the Cheshire peninsula of the Dee and Mersey; while the river Severn also may be considered an inland drain of the red sandstone group. It skirts also the south-eastern borders of the Cornish and Devon primary Isle, by the vale of Exeter and Taunton. In the valley of the Solway Frith and the Eden too, red sandstone marks the line of deposition and tide-wave in a distinct manner; and on the south-west shore of Cumberland, from Saint Bees to the estuary of the Duddon, it lies upon and skirts the primary Isle of Cumberland.

A glance upon the features of deposition, either generally or in detail, at the close of the tertiary or sandstone formation in the construction of England and Wales, yet sheds an intelligible light on the former courses and bearings of tidal operations. At the close of the sandstone formation, as now constituted, England and Wales for the first time assumed the figure of a completed Island. The newest of this series—new red sandstone, may be considered the centre of a Geological arch. At the same time we become acquainted with some of the modes by which a constructive power has conducted the processes of creation.

In reviewing the sandstone series generally, or the tertiary formation more properly called, it would seem that the tide-waves of the north and south Irish Channels had brought little or no drift-wood upon our western shores. Such drift-wood had probably been embayed and stranded in Scotland and Ireland, ere it reached a more remote destination. Looking at the figure, the position, and general incidents which belong to the Cumberland, Lancashire, and North Wales coal-fields, it may be inferred that the tide-waves of the north and south Irish Channels met in Morecambe Bay in early periods of time, as they do in our own day.

Facing the bay of Liverpool, in Denbighshire and Flintshire, the terminations of mountain limestone and the coal measures are curved off, as if cut away by a tidal eddy. On the side of South

Lancashire, between Formby and Preston, and in continuation across the valley of the Ribble, the coal is curved off and cut away in a similar manner; and also facing the river Mersey for 20 miles to the south-east of Formby. Within the extensive area of red sandstone, into which the Dee and the Mersey lead, it would seem as if four distinct tide-waves had met there; namely, the North Sea, the Irish Sea, the Bristol Channel, and the British Channel. Hence the meetings and directions of these tide-waves contributed to facilitate the deposition of new red sandstone, and various groups of still older rocks.

As the tide-waves of the north and south Irish Channels met in Morecambe Bay, and appear to have brought no drift-wood along with them, so not only that bay but the whole line of shore from Whitehaven to Formby is wanting in coal, the Isle of Man as well, and the south of Scotland. There is no evidence, therefore, of any of the material of coal having reached the Irish Sea by the north and south Channels. Such facts, by the way, are exceedingly striking, and go to confirm the theory of tidal deposition here adopted.

When we view the figure and extent of the ground assigned to a tertiary formation in England and Wales, it appears so generally distinct in itself, apart from antecedent and subsequent formations, that its claims to a generic class in Geology may be considered unavoidable, rather than a mere arbitrary rule of abstract science; the more especially as the primary formation finds England a few detached rocks only, and the secondary formation but a set of limited and detached isles, which the tertiary formation have joined together in a compact and well formed island. Moreover, new red sandstone for the first time completed this great work in the tidal construction of our island, all but completed its western shore, and drew a distinct line between the tertiary and newer formations on a south-east section of England. Classification in Geology viewed so, not only entitles us to consider the sandstone series a tertiary formation, but that new red sandstone finishes the centre form of science, and places the keystone in the arch, bounded by limits and lines distinctive in themselves, as applied to England and Wales.

Treating on the order of science, and having come to a fourth formation of rocks, while we shall apply a term thus plain, we submissively propose to Geologists, the designation of a Quartary formation; adding another, termed Quintary formation, or a fifth Geological class.

The fourth Geological formation is distinguished in its composition by a more frequent prevalence of calcareous earth, more clay in a finely divided state, less silicious ingredients, and more abundant traces of organic remains. The heights attained by the groups of rocks in immediate succession to red sandstone hold an elevation which does not warrant any material subsidence of the oceanic level during the deposition of the later groups of the tertiary formation. Red sandstone commonly holds a depressed level, compared to the rocks which precede and follow it. Yet that may in a great measure be attributed to the specific gravity of the silicious grains or crystals of which it is chiefly composed. These would have a tendency to submerge on a low level; while a more recent group, as shown in the eastern moorlands of Yorkshire, is elevated as much as 1485 feet above the level of the sea.

On the completion of the red sandstone group, the western coasts of England and Wales appear to have received no accession of rocks, such as the fourth formation are composed of. It may be, therefore, inferred, that this formation has been brought by the tide-wave of the North Sea from Polar deeps; and projected in lines from the range of magnesian limestone at Hartlepool, along the south-east shore of England, until cut short and bisected by the tide-wave of the British Channel, flowing around Start Point on north-eastern bearings, or that of the Bristol Channel falling into and taking the course of the former; while the tide-wave of the Irish Sea had probably ceased to exercise any material influence on that of the North Sea, further than a preservation of common levels. Agreeable to these terms, the lias, oolite, and chalk groups occupy a broad line in a sort of crescent-like form, lying between the river Tees on the north-east, and Start Point on the south-west—the pivots on which an eastern and a western tide-wave have rested. The fourth formation is the broadest about its central range; and though terminating in a blunted shape on the north-east, its south-west terminus is in some measure tapered off.

Accordingly as the process of deposition advanced, the meetings and operations of an eastern and a western tide-wave would be liable to vary their ground and form of action. Hence the centre of the great crescent, which contains the fourth formation in England, may be estimated at 80 miles across; while taken on the line of tidal deposition from Hartlepool by Market Weighton and Mount Sorrel; and from Start Point by Lyme Regis, Gloucester, and Mount Sorrel, it may be said to almost taper off to nothing. Consequently, the meeting ground of an eastern and a western tide-wave has had a strong tendency to go out on the south-east, from the Isle of Anglesey originally, to the Strait of Dover finally; or from Start Point to Berwick-upon-Tweed; two headlands on the primary Isles, which had acquired no land whatever, while all the rest of the kingdom to the eastward thereof had been gained from the great deeps. Indeed, it is obviously an ordinary law of physics that a tide-wave projected from the north, and another projected across its line of operation from the west, though meeting at the outset on a slight curve, must finally force each other out at a right angle, or until the talus deposited between them imparted a common line of direction to both; and that still more decidedly in case a subsidence of the oceanic tide-wave were continuously progressive.

In correspondence with such a law of tidal action, it would appear that a western tide-wave had projected the material of the valley of the Weald eastwards; and next deposited a range of chalk upon its southern borders; whilst an eastern tide-wave operated upon the northern borders thereof, and carried out a range of chalk to Dover, when both these lines of deposition were necessarily cut short by a consimilar operation having been at the same time in progress on the side of France. It is therefore to a progressive subsidence of the ocean, operating conjointly with the peculiar directions and variable action of an eastern and a western tide-wave that we are to attribute the figure and position of the valley of the Ouse in Bedfordshire and Cambridgeshire; the main outlines of the basin of London; and various lesser basins of the same sort which are found in the south-east section of England adjacent to the cretaceous group of rocks. We may here close further details on what may be perhaps appropriately designated a quartary formation, or the fourth order in Geology.

The fourth class of rocks, as here described, complete a Geological section of England lying to the south-east and adjoining the red sandstone group, apart from still more recent diluvial beds.

These several considerations point out the propriety of placing lias, the oolitic, the weald, and cretaceous groups of rocks in the same series. Nor does any antecedent formation show the actual range of tidal currents more distinctly, during a period of deposition, than the class which has just undergone our review. They are not only delineated by lines exceedingly exact in themselves; but also illustrate those considerable variations in tidal action to which we owe so much of the fair figure and extent of England.

Apart from the fourth formation, which has taken a crescent-like form, with a tidal limb running through Hampshire, Wiltshire, Sussex, and Kent, stretched out to Dover, the rest of the south-east section of England is occupied by those diluvial beds and alluvial deposits, which close Geological classification in England, and present a fifth formation in Geology, or a Quintary series. First, then, we have the granite formation disentombed from the bowels of the earth; next a secondary formation, smoothing up its vacancies by tidal depositions, and forming those primary Isles, which a tertiary formation joined together. To these formations, in England, a calcareous and aluminous series have been added, like another Isle in themselves, and fitly compose a fourth class in Geology; closed by those remaining deposits, diluvial and alluvial, which are kindred and inseparable in form and materials, differing only as an older and a newer formation. These we shall throw into a chapter by themselves; and give more immediate attention to such general notices as arise out of that which has been already in hand.

It has been previously suggested that the present equatorial movement of the earth may not have been always the same; and that it has been probably swung round by the force of tidal action. The extraordinary course of tidal currents from south to north favours such a view of the mechanical movements of the globe. Had the main granitic lines on the Old and the New World been parallel to each other and detached, the Atlantic Ocean might have been the equator. During the prevalence of the highest tide-wave that ever existed, this may have been so, and left traces behind as concerned its elevation which now seem unaccountable. But on the subsidence of the oceanic level by deposition alone, and the cavities into which the tide-wave necessarily sunk, the North Pole lying encircled by iron barriers, would necessarily cause the earth to swing about, and establish those tidal currents which flow from the south in the direction of the North Pole and return again. Thus much granted, the same rule of tidal forces, which evened the Norwegian chain by an accumulation of primary deposits, and strengthened its powers as a tidal barrier, may have strengthened the spinal system of the Old and New Worlds, and prepared the way to those steady movements we now witness. Nor is such a theory at all inconsistent with the existing phenomena of the earth, and gives a ready answer to objections which might be otherwise taken. Showing at the time, how easily the Almighty will might poise the earth, like some huge rocking stone, and grow forests of pine, which an irregular action swept away, and restored the ground again to its previous uses. Whether from north to south be considered polar pivots, or an equatorial range, the action and courses of tidal currents would be precisely the same; and even granting these suggestions fabulous, it proves the mighty means and ends which lie within the grasp of Infinite wisdom and goodness supreme. In the hands of an Almighty will, the earth might be wound up and spun as a school boy would his top, thus preparing in the womb of creation those beneficent ends we now witness. We may believe and tremble! Vanity and ignorance can alone doubt and deny!

In the Geological structure of the Continent of Europe, on the north of France, Cape de la Hogue is fortified by granitic barriers, which are plainly in lineal operation with those on the side of Cornwall and Devonshire. Commencing on this Cape, and through central France, taking the line of the Alps in conjunction with the Hartz, the Bohemian, and Carpathian mountains, a line of primary, secondary, and early tertiary formations, without almost an exception, hold a high level through France, and across Europe to the Hellespont. On the eastern range of these central barriers, France possesses several fields of coal, which may be traced to the same origin, and brought on the same tidal courses as those connected with England.

In the neighbourhood of Namur an extensive field of coal commences, which extends beyond Leige; and reappears at Aix la Chapelle and Dusseldorf. It then traverses the valley of the river Roer, in Westphalia, for 30 miles in length and 17 in breadth; and contains above 80 seams that are worked. Some of these are seven feet in thickness. Still trending in the same direction, coal is found in Saxony. In continuation along this great line, by the valley of the Elbe, the material of coal has made its way into Bohemia. Carried along the valley of the Oder, it has reached Upper Silesia, and extends into Moravia, where the interposition of the Carpathian mountains has obstructed the further extension of carboniferous coal in this direction. It terminates at this point both eastwards and southwards; resting as it does on primary bulwarks which have cut off its further elongation. In the map of the granite formation herewith given, the reader will find a general outline of the great coal formation traced out, from the north of Scotland to the Carpathian mountains. But it must be regarded as a merely general range.

A body of evidence sustained by facts so multifarious, would seem conclusive as to the origin of coal, the material of which it is composed, and the quarter from whence an almost interminable supply has come. Looking towards the position and bearings of the granite formation in Norway, strengthened and completed as it has been by primary deposits, and that it determined the course of a vortical current bounded by the ocean alone, floating along its stream vast forests of pine, the origin of coal is satisfactorily accounted for. Placed under the influence of prevailing forces, as the earth has been, with the deposition of a vast preparation of loose materials in progress, while a suspensive balance of an atmosphere was forming, and shifting from Pole to Pole, as drift must then have done, great disorders in the earth's motion can scarcely be questioned, which are now rectified and steadied according to constant laws. Indeed, in the variations of the needle, we probably witness those changes in the set of oceanic currents, which once constituted a mighty instrument of power, wielded according to the will of creative wisdom. Even no very material change in the polar balance, might augment the temperature of northern regions, diminish the elevation of the tide-wave, and for a season promote a vast growth of pine. Reverse operations on the contrary might suddenly raise the tide-wave, and plunge those forests, from the Lena to the Oby, that now provide fossil fuel for the most enterprising nations on the face of the earth, in a wide spread and devastating deluge, which swept off their products and strewed them on distant shores. Geology so viewed is a mechanical and mathematical science, determined by a rigid system of physics throughout.

We shall make no attempt to trace the southern formation, the carboniferous limestone groups, the oolitic and cretaceous series, around the great basin of Europe, from the Ural, along the steppes of central Asia, and through Germany and France. It is enough to have shown the course of tidal deposition. Hence, further proofs may be left to those researches which the labours of future Geologists are, we trust, destined to undertake. Let a general theory be once fairly established, exact details are then certain to follow as common consequences.

A rapid advance has assuredly been made of late years in a collection and classification of evidences obtainable in natural history, which have contributed to shed much light on periods, when the earth has gone through various changes in the onwards work of creation. So far this is well. It has, nevertheless, been attended by defects which confuse Geology as a pure science, resting on mechanical and mathematical deductions, and a suitable classification of distinct formations. Whilst first premises then continue to be slurred over and but obscurely understood, splendid details and high sounding language may be compared to elaborate chisselling and superb cornices placed on rude pediments and disjointed fragments. Without touching those elaborate investigations, it is our purpose to give them appropriate places, rather than plausible and wire-drawn inferences, traced from merely curious and isolated facts. Nor is it less true, that in putting forth a comprehensive theory, obvious and striking defects may occur in speculative detail, intended to point out the path to future truths, rather than an arrogant assumption of demonstrated laws or causal incidents. It is not possible to view the configuration of the earth in general, the electric courses which probably originate therein, the circulation of a suspended atmosphere, and oceanic currents, determined by physical laws, without being satisfied that these are intimately acquainted with the economy and mechanical working of the globe.

Granted that the physical figure of the earth be an oblate spheroid, according to strictly mechanical principles, the distribution and height of land is such, that any equatorial change would immediately resolve itself into a mere change of oceanic levels. Suppose the line of the equator laid along the Atlantic Ocean, the elevation of that level would rise on tidal laws, and flatten in the Pacific and Indian Oceans. Hence it cannot be questioned that a variation of a Polar axis would not interfere with the oblate spheroid of the earth's figure. A change in oceanic levels would conform to physical differences, and preserve the earth's outline as before. Nor can it be doubted that a greater or less velocity of oceanic currents may materially vitiate the question of the earth's sphericity. Suppose on the opposite shores of the Isthmus of Darien a difference in sea levels, is found to exist, which of these two levels shall decide the form of the globe? Any isolated measurement of a degree cannot therefore prove that form, until the whole levels of land and water are first taken, since the greater or less velocity of oceanic currents may give out fallacious results. Owing to such incidents, while the general figure of the earth is admitted to be spherical, that which is actually presented is irregular in form, because the line of slow moving water must be flattened; and that of comparatively quick running water more lengthened and round.

It is the relative figure of the dry land of the earth, therefore, rather than its mere elevation on this or that point, which determines the course of tidal action to be from Pole to Pole, or to and fro in the direction of the Poles. The variations of the needle prove that some fluctuating bias interferes with the balance of Polarity; and why may not those variations have been much more considerable, ere a great subsidence of the oceanic level were more regular and steady? The very fact of the physical form of the earth being an oblate spheriod, and tidal action swinging it more or less around, proportionably as that action varied, and variation must be admitted, an intermitting elevation and depression of the tide-wave follows as a consequence. Periods of wonderful vegetable exuberance on vast spaces of dry land, may have therefore been succeeded by devastating torrents, which despoiled one region of its forests, and swept them on foreign shores. Hence the material of coal is plainly accounted for. During a process in which prodigious masses of loose materials, now reposing in various Neptunian formations, were successively swept from Pole to Pole, as concerned an equator of the earth, and an atmosphere composed of balanced forces, they were probably affected by material irregularities, which are now steadied and rectified by constant laws. Under prevailing incidents so disordered, causes of sudden and overwhelming deluge by no means appear unaccountable, when the very Poles of the earth might be liable to vary, and disturb the tidal action of the entire globe.

In the early ages of the earth's composition and reconstruction, so many ages are by no means required to perfect the comprehensive ends disclosed to our view, as an imperfect glance on the subject suggests. Mystery on mystery gives way, when accounted for on plain principles, until the interposition of Infinite wisdom is satisfactorily explained. It is true, in the hand of providence extent, matter, and time are trivial considerations, yet the ways and means of Infinite wisdom applying these to bountiful and beneficent purposes, would seem always employed, and therefore unnecessary delay is an erroneous assumption. Were the age of the earth divided into two equal eras, the non-habitable and the habitable globe by man, the first period of time would appear quite adequate for the full maturity of the world we enjoy. Can we detect organic order and design in the construction of the earth, it may be asked? We answer in reply, they cannot be denied. The earth is framed on principles of perfect mechanism throughout; and our denials extend but to ignorance of that mechanism. The wisdom we are unable to comprehend, we are too prone to doubt. The earth must be considered a non-sentient being, and therefore incapable of fabricating a system within itself by any sentient qualities it may be endowed with, such as craving to satiate wants and desires of which it is conscious. The more truths we know, the more we believe in God's mercy and wisdom.

In the hands of Infinite wisdom, the agency of electricity alone, with a few instruments equally effective, place a directing control over the globe, not only of organizing and framing it on omniscient principles, but of applying like means to the entire planetary system, and all that reigns within and beyond its vortex. Mr. Dalton has explained that atoms differ in volume. This very difference may probably enough be the means by which an Omnipotent and Omniscient Architect fabricated a universe, merely setting active atoms to work in driving more sluggish ones into masses and clusters. This great truth in physics may be aptly illustrated by the mode in which oceanic powers, wonderfully active in themselves, have driven heavy but inert masses of matter to places of rest, and there deposited them in fixed repose. As applied to light and heavy atoms of matter, the individually weak, yet active and united few, have overcome by the application of just and attainable means the individually strong, but sluggish many; and converted them into the order and harmony of an organic world. Such are the antagonist principles by which Neptunian forces have fabricated the dry land of the earth, and fitted it, according to God's wisdom and goodness, for the abode of industrial, peaceful, and civilized nations, like unto God's own works and image, drawing good purposes out of a war of elements, in which even strife is subdued by right, and the works of man rendered organically happy in a government composed of civil bonds wisely free, yet socially safe and secure; yielding unto every man the fair fruits of his industry, protection to his person, the careful improvement, custody, and security of his property, and the free commercial rights of mankind on terms reciprocally beneficial and happy to nations. Man in the pride of his heart, the mistaken folly of his nature, and selfishness of his purpose may resist what is so harmonizing and just. But the infinite wisdom of our Maker has willed it otherwise in the end, and he will prevail.

In the application of agents so effective as those which lie at Heaven's command, the high induration of rock slate may have been speedily effected, as hardness is far from evincing length of time. By the electric saturation of a primeval world with that all-pervading and powerful element, the primary formation may have been upheaved by a single discharge. Then Jove's thunderbolt, the lightning's force, might play from hill to hill, from pole to pole, in smooth and fluid circles, which suspended the elements of vitality, and created a respirable atmosphere. Even a portion of those very waters, which had been an instrument for extending the dry land of the earth, having done their office, ascended on high, took an aerial form, extended the surface of the dry land by their absence, shielded animated nature from the stroke of death, and imparted to us the means and pleasures of animated being—respiration. Then the elements of nutrition were provided — carbon. And that nothing might go to waste, and stores of superabundance for ever remain, its surplus has been east into the affinities of calcareous earth, and laid to the face of day, ready for use on all apt occasions. Accordingly, as the sea receded, the hills rose in comparative elevation, the electric sphere acquired additional extension, the waters of the great deeps were suspended on high more plenteously, and fruitful plains arose from the bosom of the ocean. Previous to this important era, and when intermitting torrents repeatedly devastated the earth, the dry land attained was devoted to the production of forests, to be preserved for the beneficial use of industry in ages of civilization and social repose.

Wise, and mighty, and comprehensive as those preparative steps and processes were, the means and the ingredients provided were in every way fitted for the creation of the earth in a comparatively short period of time. With a profusion of materials, assorted by fluid action into infinite classes proportioned to their activity and volume, rather than their constituent elements, along with chemical agency directed by eternal Omniscience, nothing was defective in framing ends so perfect. Life and form do not originate in necessity. Chance is chaos. Order and harmony spring from providential design and goodness supreme. Ignorance may deny conclusions so inalienable; but shall we not believe, expound, and kneel down in grateful adoration before so much blessedness and wisdom. An organic balance in the body and mind of man, which affords so much activity to the one, and qualities so scientifically, morally, and religiously refined to the other, so as to bring out the social sympathies with which he is endowed, are not more requisite to the little system within himself, than like powers centred in a Godhead are necessary to the government of the universe. Granting that the universe be composed of active forces, it is nevertheless as necessary that mind should exercise a full control over this incomprehensibly vast machine, even in its most minute details, as over the smallest nerve of the corporal body. Nor can human reason extend further than either act upon this organic framework, or contemplate the wonderful balance and perfection of its working powers. These lead him to eternal truths, and render him a fit agent of God's will and power.

Time has certainly been less concerned, and is less requisite, in the work of creation than the mere philosophy of man has hitherto accepted. Be it also observed that time is an instrument of decay, as well as a generator of organic being. In the development of providential laws, time has been unquestionably employed under due qualifications. The conversion of ravaged forests into coal by chemical agency, might demand no very lengthened space of time; 500 years might be quite enough. For as we are but limitedly acquainted with the leading processes of nature, so may we commit gross mistakes in skipping to hasty conclusions, and in assigning to nature apparent processes which required lengthened time; whilst the entire fabric might be completed in a few hours. Could we be brought to believe that chance had caused this or that end, the uncertainty of a happy juncture turning up incidentally, might suspend events for millions of years ere a lucky hit obtained. Nor do we observe that unnecessary suspension employed in the fabrication of the earth, which philosophy is prone to assign. A regular series of incidents follow one another successively, as if the whole had been contemplated by Infinite wisdom. The subject so considered, the fair deduction is that the creation of the earth has been accomplished in a relatively short space of time.

Viewed in the early stages of creation, can we attribute order, harmony, and design to chance—the parent of dislocation, misshapen phenomena, and rude chaos? Or shall we compare it to the embryo in the womb, in unconscious repose, while progressing towards a future state of maturity? Or did the earth contain within itself a perfect system directed by foreknowledge and vitality nurturing its growing strength? No! No! These are idle and but philosophic dreams, in which fancy may indulge at the expense of sober truths. The hand of Infinite wisdom, holding the direction of proper instruments, and provided with a superabundance of the fittest materials, has fashioned out the universe, fabricated like a potter's vessel on a wheel, to be afterwards hardened and finished for its intended use. That Geology leads to a conclusion thus figuratively expressed, can scarcely be denied.

In tracing the construction of the earth from its primitive skeleton to the perfections now shown, a constant tendency towards a more settled order of things may be distinctly observed, and its ruling principles becoming more organic and secure. Even social organization, as brought out of savage barbarity, seems to partake in a like course of events. At each movement the action of the earth has become more steady and harmonious. God has not doomed his creatures to meet higher and higher dangers; more and more impediments and deprivations; but multiplied and multiplying enjoyments and security. He could never designedly disfigure his works, and leave them a prey to augmented defects and disorders; and if we cling to consoling deductions, we believe them to be sustained by undeniable truths; and shall cordially pursue the thread of our narrative, under a conviction that "in God's hand are all the corners of the earth: and THE STRENGTH of the hills is his also. The sea is his, and he made it: and his hands prepared the dry land." Geology leads to these inalienable acknowledgments, as well as that God's will is the most devotedly applied to purposes of universal benevolence. Hence we constantly observe in all that pertains to man, the mere selfishness of individual utilitarianism, put right and conservated, even according to its own assumed propensities, by that devotional goodness and sympathy of heart, which elevates man in the abstract as truly as it s him honour individually. Benighted philosophy may not accept such principles; but though man has a selfish disposition, he has also a candid and disinterested one, added to a love of order, harmony, and just government, opposed to destructive changes made on idle and defective principles.

We may here notice that the Isle of Wight along its centre, from west to east, and to the south thereof, is chiefly composed of the fourth series of rocks, deposited by a flux and reflux tide-wave along the northern shore of the British Channel, as shewn in the elaborate and beautifully constructed model of the under-cliff, by Mr. Ibbetson of Regent Street, London. Some may say that the stratification of the under-cliff has mostly a dip; and has therefore undergone disturbance subsequently to its original deposition. But as shores of the sea are commonly shelving, such a deduction would do any thing but prove volcanic force to have uplifted the whole of these beds equally; whilst the splendid model just named exhibits none of the strata in a state of disorder and dislocation. If this be granted, as the summit ranges of the under-cliff exceed an elevation of 800 feet above the level of the sea, a former tidal-wave surpassing that height follows as a consequence.

CHAPTER IV.

ON THE DEPOSITION OF DILUVIAL BEDS AND ALLUVIAL PLAINS.

THE fifth, or quintary formation, in the south-east section of England, is so distinctly an addition to our island, more recent than the cretaceous group to which it succeeds, as to leave no doubt where the diluvial beds begin, and where the fourth series end. While the fourth formation is projected forwards from Hartlepool; the fifth formation is similarly projected from Flamborough Head, comprising the diluvial beds and alluvial districts of Yorkshire, Lincolnshire, Northamptonshire, Cambridgeshire, Huntingdonshire, Norfolk, Suffolk, Essex, and the basin of London. Thus far we find a tolerably compact diluvial and alluvial Isle added to our eastern shores. Here no mistakes in classification can creep in. The Geology of England, and of the world at large, may be readily divided into five distinct orders of creation, ere man is found among the fair fruits of a Creator's handyworks. He appeared; and marked the sixth period of creation. The seventh is the age of Geological repose—rest. It is idle and futile in Geologists to either overlook or disregard lines so conspicuously drawn out; and liable to no doubts whatever.

An inspired author is correct in science and in theology; and we have but to follow the extended outline he has so ably described, to come at right deductions on what we shall add in detail.

To proceed, on the shores of Kent, Sussex, Hampshire, Dorsetshire, and the Isle of Wight on the north, we meet with diluvial beds which have been projected from Bridport by the tide-wave of the British Channel, on tidal laws similar to the projection of the Chesil Bank. Along the southern escarpment of the chalk range from Bridport to Brighton, have those sedimentary deposits accumulated which mark the limits of the fifth formation in this section of the kingdom. Perhaps having in this place marked out a free outline, it may be unnecessary to enter into details, which may be said to almost describe themselves; and we shall accordingly take a more detailed view of the diluvial beds which cover the plain of Wigton, in Cumberland.

An out-crop of red sandstone, commonly more elevated than the range of diluvial beds on the north thereof, is formed on a direct line from the parish church of Dalston to that of Cross Cannonby, the parish church of Maryport. On all points of this line the red sandstone is at short intervals exhibited to the day, and numerous quarries are worked along the entire line. If a parallel line be taken one mile more northwards, it passes through the town of Wigton, seven miles from Dalston, and 12 miles from Cross Cannonby. Along the course of this parallel line, the red sandstone is uniformly overlaid by diluvial beds. These beds commence overlying the red sandstone at Cummersdale, 10 miles east of Wigton, and close to Mealow, 11 miles west of Wigton, on the shores of the Solway Frith. Hence the diluvial beds overlie the red sandstone on a right line 21 miles in length, from Cummersdale to Mealow. Passing through the town of Wigton, not a single sight of red sandstone has been obtained along this latter line. Hence the prevalence of red sandstone on the former line, and its being totally hidden on the latter, proves that the course of tidal deposition has in this case been on a direct line 21 miles in length. Though repeatedly crossed by upland currents from south to north, which break the lines of continuous ridges into patches from half a mile to two miles long, yet the course of each patch uniformly corresponds with the line of deposition, or tidal action. So orderly are those ridges formed that no grounds of subsequent dislocation are admissible. They seem to have come fresh out of the hands of Neptune, lying in undulations from north to south, from 100 to 300 yards in breadth, and elevated from 30 to 50 feet above the gentle vales which separate one line of ridges from another. A flowing, an ebb, and subsiding tide-wave, have obviously formed those diluvial ridges, in the early courses of the Solway Frith. No sooner do the rivers Eden, Petteril, and Caldew cross the line of eastern and western deposition, from the southwards in northward courses, than the ground becomes rounded northwards, and indented on the south of Scotland. So that the plain of Wigton is rounded off eastwards by those inland drains, and westwards by the Solway Frith. Wigton is about half a mile east of due north from the trigonometrical station on Skiddaw, the distance is 11 miles; and it is 9 miles more along the same line to the shores of the Solway Frith at Bowness.

Ascending from the Solway due south, on the trigonometrical line of Skiddaw, for 13 miles to Catlands, a summit rock of the carboniferous group, on a transverse section of the diluvial beds, to the foot of which rock from the Solway they extend, there is obviously a general inclination to rise step by step until these beds attain an elevation about 600 feet above the level of the sea. Above this height they may be said to disappear. That the diluvial beds of the plain of Wigton so regularly formed, so consistent with a previous flow and ebb of the tide-wave in the Solway Freth, are of Neptunian origin seems undeniable. Well. At Catlands the coal measures have been gone over, and which the diluvial beds commonly overlie; and we are now brought to an escarpment of carboniferous limestone. Shall we deny that the same flow and ebb of tide has in a like direction thrown a regular zone of limestone around the northern extremities of the Cumbrian primary Isle? If so much be admitted, an acknowledgment of a tide-wave 2500 feet above the present oceanic level follows as a consequence; and then shall we deny one still higher, forming ridges of like figure, features, and materials, as the diluvial beds upon the plain? The affirmative is equally undeniable. Therefore, a primeval tide-wave must be admitted to have pervaded the earth, as much as 3500 feet above the present level of the sea. The strictest examination of these premises on the ground itself, will appear still more convincing to the eye, and conclusive in deductive investigation, than any verbal description can supply. As a general rule, the more truth is handled the more plain it appears. This is precisely our case. The whole group of the Cumberland mountains, the zone of limestone determined by the water-shed of Saint Bees Head; the zone of carboniferous coal which exactly corresponds; the red sandstone overlying the coal measures trending around previous groups of depositions; and the course of diluvial beds again conforming to the same order of things, with the tide-wave of the Solway and the courses of the rivers Eden, Petterill, and Caldew, all corresponding to a theory exactly and entirely proved throughout,—a denial may be still pronounced, but truth is nevertheless ready to assert its common claims. The valley of the Solway, viewed in a primary light, as extending to Kirkby Stephen in Westmoreland, affords as regular and complete an instance of tidal results as can well be conceived.

Opposite to Bowness, the Scotch shore of the Solway Frith is all but entirely denuded of diluvial beds; while the same appearances of denudation in no degree appear on the side of Cumberland (due south, and bearing on Skiddaw,) at a less distance than 10 miles inland, and even then but partially. The main depositions on the northern shore of Solway, westwards of the town of Annan, meagre as they are, do not consist of diluvial ridges, containing fragments of the secondary formation, but fragments of the tertiary formation, on which they rest, thrown into complications of sandy knowles without order and form. Why? Because the tide-wave from early ages has abutted on this shore; while the primary Isle of Cumberland has gathered deposits on its northern aspect, until it nearly reaches to the base of an opposite primary Isle on the south of Scotland.

The diluvial beds on the plain of Wigton are composed of materials which preclude any vulcanists denying deposition by a high tidal level. These beds are obviously debris, derived from attrition on the escarpments of the south Scotch and Cumberland primary Isles. Not only are the aluminous and silicious earth, of which these beds are chiefly formed, derived from the poundings of secondary rocks, but they are full of rounded fragments from the same source, including every specimen, from granite to greywacke, which the primary Isles on the north and the south of the Solway afford. The flow and ebb of a high tide-wave, coupled with mountain torrents, have superinduced a body of materials above the tertiary formation, from red sandstone to millstone grit, which are older and totally distinct from those groups. It is in vain to seek among the mountains on either side of the estuary of the Solway, on the same spot, for that variety of Geological specimens which the plain of Wigton affords. While descending torrents have issued from vast and multiplied ravines at the various gorges of these mountains, a flowing tide along the coast of Scotland, and an ebb tide from the inland drains of Cumberland, by reciprocating tide-waves, have compounded a foreign mass, if we may say so, in the most complete manner conceivable. Red sandstone must have then been the base upon which tidal action worked its operations, affording at the same time some of the aluminous and silicious materials required; yet all the fragments of rocks first rounded by attrition, belong to the two oldest formations, though immediately resting upon a base of red sandstone. It is obvious, indeed, that most of the materials which have gone to form diluvial beds on the plain of Wigton, have been brought from a distance. Seldom less than five miles, and from that to 50 miles, as from the valley of the Cree in Scotland. The size and number of boulders, often as much as a ton weight, strewed over incredible elevations, might stagger belief in the means by which such ends have been produced, were we not at the same time fully assured of the vast powers which lie within the influence of tidal effects. It is also obvious that some of those large granitic fragments occasionally met with on the plain of Wigton, as some writers contend, may have been floated on icebergs to the positions in which they are now found; yet the main portion of boulders found in and on these diluvial beds, have evidently been rolled to their present localities by tidal operations. Even at the very gorge of the river Caldew, at Dalston, while the bed of the river is red sandstone, as well as its banks, all the fragments of rocks which repose on that sandstone, belong to the adjacent primary Isles. Distinct and obvious as these facts are, whether as subjects of curiosity, instructive lessons in science, or a better acquaintance with the economy of creation, they excite our highest contemplation and interest, pourtraying the simple and vast means which lie within the reach of Almighty wisdom and goodness. To silt up and convert into a fruitful soil the once spacious estuary of the Solway Frith, the violent forces of Neptune, conjoined with devastating torrents, have been employed in bringing vast masses of debris from the mountains, and scouring up the recesses of the great deeps. Physics are unquestionably the instruments that work. But do they not work also according to intelligent principles? The provident result is certainly evinced in smiling industry, social blessedness, and religious gratitude to Him who has bestowed so much.

Torrents on so high a level as 600 feet above the present level of the sea having obviously prevailed subsequent to the final deposition of coal, it may be asked why should drift-wood not be found either embedded in or along diluvial depositions composed of clay and sand? The answer is, that those diluvial beds are mainly divested of organic remains. Along their northern edge, however, and on corresponding levels adjoining the borders of the Solway Frith, extensive tracts of peat mosses are exhibited, which indicate an early deposition of ravaged forests above the diluvial beds. Weddom flow occupies an area of about six square miles; Bowness flow, nine miles; Glasson moss, four miles; and Fingland moss, about two miles; making together about 21 square miles of those peculiar peat bogs. The noted Solway moss on the Scotch borders, would seem a continuation of those mosses, with the Solway Frith intervening between them. Pilling and Chat mosses in Lancashire indicate a similar origin. None of these great bogs being altogether land-locked, have a free current of water from them in almost every direction, lie on the same levels, grow antiseptic plants of the same species, produce an abundance of heath, are divested of culmiferous herbage, are uncommonly soft and pulpy without any assignable cause, and differ essentially from such land-locked bogs as are found even adjoining them; a fair conclusion is, that they belong to the same age of the earth's reconstruction, and are consimilar in origin; namely, drifted forests stranded to a considerable extent where those mosses are situated, and which have destroyed culmiferous vegetation, leaving antiseptic plants to prosper in place thereof, and prepare remains that now form the material of deep and slouchy bogs. Laying on the same levels, being on the borders of estuaries, considerable in extent, and uniform in general features, with like products to their very edges, favour the views here taken exceedingly.

Fluviatile plains depend on modes of deposition so ordinary and recent, that we may be allowed to pass them without further notice. Marine alluvian is very different. These depositions are disposed of by oceanic currents, which involve the most intricate tidal laws. We would in this place humbly state that no term has probably contributed so much to confuse and retard physical science, as that of the attraction of gravitation. The invention of this mystic term appears to assume some unknown influence in physics, leads to obscurity unnecessarily, and checks the progress of pure knowledge divested of abstruse riddles. By what power or powers do bodies attract one another? In its applied sense, the attraction of gravitation is altogether a plausible term without a real idea, and therefore unphilosophical. We do not say that the mighty plain of western Europe has been deposited by the force of oceanic attraction. Yet why not say so? Because we are acquainted with those fluid forces which have propelled the debris of the Atlantic Ocean and the Polar Seas on a line of primary barriers that checked fluidity, and caused the deposition of a repulsed mass of materials.

Forces of gravitation, on consimilar principles, and conformable to centrifugal and centripetal laws, impart to easily divisible and active atoms the power of driving less divisible and more sluggish ones into the various masses which compose the planetary system and its members. Hence, if water drive into masses the earths, by the same law electric forces drive water itself together. Probably enough, the most divisible and active atoms being defective in dense forces, are continually driven to the sun by those less divisible, and there receive that amalgamation and composition, which sends them forth again to the different members of the solar system, where they are ground down and redivided, until repulsed by more dense atoms, they are driven to the sun. Let this be admitted as fanciful, it does not the less assert the principles of action and reaction regulating the affairs of the universe.

As the forces of gravitation have separated the waters of the earth from its dry land, and steadied them in their respective positions, why may not a similar law obtain in the economy of the universe? The ocean is continually engaged in scouring out its own deeps, and driving the material thereof on dry land, to extend and enrich the area of that land; whilst intermitting torrents bring debris from the hills that compress and limit the tidal wave. Effective forces so far work in the plainest manner. What is so powerful in one form may equally well apply, where masses of matter are engaged in driving each other about in circles, which steady and regulate each other. We are assured that they move according to strict laws, and we may safely go further than assigning them the mystic energy of the attraction of gravitation, and conclude that the forces of gravitation ever work on organic and intelligent principles.

If regulated forces so universal be admitted in place of the mysteries of the attraction of gravitation, which but assume a fancied influence, instead of an effective and real one, we are distinctly led to tidal pulsation, or the laws by which fluid atoms reciprocally repulse each other, and drive sluggish matter into dense aggregates Circular action contributes to strengthen centripetal force, because it infinitesimally propels atoms obliquely, and on an inner angle. Not overcoming entirely the tendency of atoms to propel each other in lines at the same time, centrifugal force would overcome the centripetal law, had not active and sluggish atoms a mutual tendency to repulse each other. It follows from these premises, that each member of the planetary system having an aptitude to bring the force of gravitation upon itself, thereby diminishes the centripetal and multiplies the centrifugal action of the neighbouring planets. The wise economy exercised in the framework of the planetary system is here apparent, as the planets are continually engaged in withdrawing an excess of pressure from each other, which might prove obstructive to the organic scheme, and either lead to partial disorders or a state of universal chaos. Whilst the moon is therefore revolving around the earth, and conservating more wise ordinations in physics than we are able to comprehend, by weakening the force of centripetal action on particular parts of the earth, and restoring it by turns, are we indebted for the leading phenomena of tides.

In estimating the influence of tidal laws on the deposition of marine and fluviatile alluvian in estuaries of the sea, by tracing the action and the effect of the tide-wave, are we to deduce the causes of some bays silting up, while others remain deep water to the very rocks which determine their boundaries. The laws of fluidity may be here traced out, whether applied to the universe, to the globe in general, or to particular portions of its surface, as the chief operating cause in the means of organic action. To observe how these laws work on the shores of Great Britain, due notice must be taken of the several incidents that belong to neighbouring oceans, seas, and estuaries. The Baltic Sea has neither ebb nor flow of tide; and a current continually sets into the North Sea through the Sound. The Baltic is therefore unconnected with the tide-wave of the North Sea. The average depth of water in the former sea may be taken at from 25 to 35 fathoms, and its greatest depth scarcely exceeds 100 fathoms. Its shores are seldom covered by water which exceeds 25 fathoms, and they are comparatively regular in depth and shallowness of water.

Deduced from these incidents, the Baltic would appear to have been considerably silted up in the early periods of the earth's formation; and that it now remains a great inland drain to the plain of eastern Europe. It might have otherwise been expected to be dry land, and covered by early depositions, the same as the adjacent plains. The numerous lakes indeed which exist between the Gulf of Finland and the White Sea, would seem to indicate depositions too imperfect to become continuous dry land. As this great continental drain meets the tide-wave of the North Sea on the southern shore of Norway, and as inland streams supply an elevation of water, which balance the intermitting flow and ebb of tides on its entrance into the North Sea, so these tides effect no perceptible difference in the general elevation of the waters of the Baltic; and the area appears to be too limited and shallow for lunar influence to act upon.

Bearing as these incidents do upon each other, it may be inferred that but little of the earthy materials borne into the Baltic by inland streams is carried through the Sound, and partly drifted only upon its shores. An opinion moreover prevails that the waters of the Baltic are slowly receding from the land, or drifting up by repeated depositions of upland silt. This is undeniably true. The Commercial Gazette of St. Petersburgh, of the 28th of May, 1834, contained the following notice on the level of the Baltic. "It has been remarked that, during the last twenty years, the water of this port has been considerably lowered, and affords a new proof of the correctness of the observations made by the ancient inhabitants of the shores of the Baltic, that the bottom of the sea continually rising, the level and body of the water is continually diminishing, and that the land is increasing on every side. According to the researches of the ancient naturalists, phenomena of this sort mostly occur in countries near the North Pole. We can quote as examples the lakes of Denmark, which have sunk so low that some of them are almost entirely without water. Sweden and Norway 2500 years ago formed one island. The town of Pittea, in 45 years became distant from the sea two miles, and the water receded from Loulea one mile in 28 years. The ancient port of Lodisa is now four miles from the sea, and that of Westerwich two miles. At the time of the foundation of Torneo, large vessels could come up close to it; now it is in the middle of the peninsula. The island of Errgsoe and Curoe, Apsoe and Testeroe have been for many years joined to each other; and Louesoe, Psalmodi, Magdelone, and many more have become part of the main land. It was upon these facts, connected with other observations, that Terinæus and Celsius concluded that the depth of the Baltic Sea diminished four inches in every century, and that in 2000 years it would entirely disappear. Although more accurate observations made in modern times do not confirm the diminution to be so rapid as this, they concur with the generally received opinion that the bottom of the sea in the northern ocean rises in a degree, though the level of the water does not sink. It is difficult to decide which two of those opinions is most correct; but it is incontestable that the main land washed by the Baltic is enlarging; that the rivers and lakes are diminishing in depth; that banks are forming in the sea ports; and that sooner or later the inhabitants of the shores of this sea will be driven to dig canals, and perhaps to lay down iron railroads in order to maintain their commerce."

The space and depth of water in the Mediterranean Sea exceed the Baltic. The former has a trifling ebb and flow of tide. But like the latter it is separated in its action from the main body of the ocean. From these facts we learn that neither the North Sea, St. George's Channel, nor the Bristol Channel, limited in space and depth of water as they are, contain within their several boundaries the causes which regulate the flow and ebb of tides. So far the withdrawal of atomic pressure, or the mystic term of the attraction of gravitation, or augmented atomic pressure, by lunar influence and centripetal action, or centrifugal repulsion, do not apply in any perceptible ratio. The causes which originate and determine tidal phenomena upon our shores must therefore be sought for extraneously. In spaces so enlarged and waters so deep as the Atlantic Ocean and the Polar Sea, which may be regarded as one continuous body of water, the loss and gain from either centripetal or centrifugal action by especial lunar influence on the fluids of the planetary system, become wonderfully active and organic in their results. It is true, what may be denominated irregularities prevail. These, however, may be distinctly traced to corresponding incidents which are apparent on the figure and features of the globe, broken as its face is into oceans, seas, and estuaries, together with the difference of curvature pervading each parallel of the earth's surface. So much variation from incidents account for the apparent irregularities of lunar interference at a glance, and need occasion no surprise. It is quite enough that we should trace especial action to its cause, though final results in detail were inconformable to that cause. The instance in hand becomes in so much a special case, and its merits must be treated accordingly.

As concerns the tidal phenomena of the North Sea, the British Channel, St. George's Channel, and the Irish Sea, since they originate in one common level and impetus, thrown off by the returning gulf stream on the coasts of Norway, Scotland, and Ireland, every difference in results must be attributed to local incidents, which the tides of those various seas encounter. Suppose the entire oceanic line from the northern extremities of Norway to Cape Finisterre on the coast of Portugal, swells nine feet in ordinary spring tides, and six feet in neap tides, the actual rise of tides on any particular shore of the British Isles must be precisely according to the original impetus given, and the local incidents it may finally encounter. The prevalence or omission of drift, must be referred to similar causes, in conjunction with the disturbing interference of land streams, and the peculiar action to which other incidents give rise.

From North Cape in Norway to Cape Clear in Ireland, and to Dover, the Irish Sea, and Land's End in Cornwall, a marked difference is instantly detected in the figure of each line of shore, as well as the prevailing depth of water. On going into still more minute details, a tendency in different places to a deposition of drift, or the opposite, is equally striking and various. On the entire range of the western frontier, from North Cape to Cape Clear, deep water prevails close upon the shore; an exhibition of iron projections and promontories all but denuded of the tertiary formation or those of a more recent date, accompanied with deep and spacious bays, possessing smooth water and secure anchorage for ships of the highest burthen, are frequently met with on every point of the compass. The entire shores of the North Sea are notoriously opposite in all these respects. Continuous straight lines of shore almost, where intervening rivers and vales are wanting. South of the Frith of Forth on the one side, and the Naze of Norway on the other, the oldest headlands and capes are composed of the tertiary formation; lines of magnesian limestone, chalk, and diluvial beds prevailing by turns, together with long lines of alluvial depositions the most modern in formation; tide harbours indebted to powerful streams of backwater for an adequate scour, almost constantly barred notwithstanding, and wholly defective in places of refuge throughout the entire sea.

The Irish Sea is all but similar in these several Geographical figures, Geological incidents, and available places of refuge for ships. On the contrary, along the south Irish Channel, on the southern shore of St. George's Channel, in the British and Bristol Channels, and on the south-east shore of the Isle of Man, we find somewhat diminished features are common, yet similar in general outlines to those which are exhibited on the western shores of Scotland and Ireland. Agreements and differences so uniform and extended cannot be attributed to a limitation of causes, and must be accounted for by original casualties in Geology, producing subsequent variations in tidal laws, and the effects flowing therefrom. A map of the British Isles shows these differences and peculiarities most strikingly, as regards both the configuration of our shores, and the depth of water which is usually found in their bays and estuaries.

As the current of the gulf stream is by and from the western shores of Norway, Scotland, and Ireland, as the eastwards motion of the earth projects the tidal wave and drift westwards, except incidents occur which avert the operation of a general tidal law, so the deposition of drift along the line of those shores is not usual. The very capes prominently advanced towards the sea, separated from each other by deeply indented bays, and composed of the earliest formations only, have assumed a similarity of form uncommonly striking, and pointed so as if they had been washed and worn by a continued current, which had flowed from north-east to south-west a million of years. A thousand capes and headlands might be named which bear these peculiar features,—although distinct from those of the North Sea and the Irish Sea. A nautical description of Bantry Bay, on the south-west coast of Ireland, may serve to show what complete places of refuge are there afforded to navigation. "The stream is scarcely perceptible in any part of the bay; the water is deep almost close to each shore; and there are no rocks or shoals in the way but what may be easily avoided—even in the night. Ships may stop any where in the middle of the bay on good ground, or in most parts near the sides." Further, "Bearhaven in Bantry Bay, is a good harbour, large and well sheltered, and good ground. The water is sufficiently deep at all times of the tide for the largest ships. It has two entrances, one at the east end of Bear Island, and the other at the west end. The west entrance is the best for ships from the westward or the southward; but the other is preferable for strangers. Anchorage may be had any where on the north side of the island, in from 5 to 11 fathoms of water." Valentia and other places on the south-west coast of Ireland afford places of refuge equally elegible and secure. Nor are those admirable harbours the effect of a violent pressure and scour of the sea. A tidal current naturally scours off drift, and bears it away in the general current of the gulf stream, by the eastwards motion of the earth projecting the tide-wave westwards. From North Cape to Cape Clear, on the eastern shore of the Atlantic, the same iron bound and jagged line, with deep bays intervening, are constantly witnessed. On many parts of the coast of Norway, as much as 200 fathoms of water is found close on shore. A decided proof how completely all drift is swept away. Deep and smooth water, affording the most excellent harbours, are the natural results; and are conclusively in favour of the theory of depositions applied to Geology in the work before us.

No sooner do we trace the features of those shores eastwards to Cape Clear, and in continuation to Tuscar Rock, than we witness a thorough change in the figure of the shore. Though still iron bound, and bays of some depth intervening, yet the line of shore is strikingly changed as compared to that of which it is a continuation; namely, from the Blaskets to Cape Clear. The cause of this difference is attributable to the tidal action sweeping along shore in the former instance, and on and off shore in the latter instance, in which case a tendency to the deposition of drift is withdrawn, and in the other increased. For though the gulf stream runs on a parallel with the western shores of Norway, Scotland, and Ireland, yet the tidal action, originating in the deep pulsations of the Atlantic Ocean, chiefly flow acros sthat stream, and simply move on and off shore. These coasts are, therefore, scoured by three distinct operations. First, the eastward motion of the earth projecting its tide-wave westwards; secondly, the gulf stream; and thirdly, the cross current of tidal action coming right on and off shore. No sooner has the tidal wave rounded Cape Clear therefore, than each and all of these especial obstructions to the accumulation of drift terminate. Nevertheless, as a considerable depth of water is retained, and drift being propelled forwards, northwards and southwards, so Kinsale, Cork, and Waterford enjoy good harbours. Youghall is barred in consequence of oblique tidal action; and Dungarvan is a dry harbour for vessels light in draft of water only. So far we trace a first step in the diminution of water along the eastern coast of Ireland.

The tide-wave coming from the vast depths of the Atlantic Ocean, having rounded Tuscar, and now running directly along shore, propelling drift forwards, from Tuscar to Ireland's Eye, a tolerably straight coast is displayed, a want of good harbours, and sand banks lying off shore trending in north and south lines. Such a range of the tidal current has obviously barred both Wexford and Dublin. Depositions are yet trifling, however, as the granite formation itself is washed by the sea of Wicklow. The tide-wave of the south Irish Channel is now thrown off the coasts of Ireland, on those of Wales and Lancashire.

It may be said that the denuded line of shore here traced from North Cape to Cape Clear is owing to the wide expanse of the Atlantic, the immense force of its wave, and the great depth of its water which is thereby obtained. No sooner is North Cape passed, and the mountain chain of Norway rounded, though washed by the Polar Sea, in which the mighty gulf stream turns, than some of the most extended fields of depositions are met with on the face of the earth. Moreover, the eastern shore of the great Pacific Ocean is equally remarkable for a large area of Geological depositions. The given circumstances under which a tide-wave may be thrown on any particular shore constitutes the main difference in results. Because a sea may be in the vicinity of the North Pole, it does not follow necessarily that there is a tendency to silt up. The great depth of water on the western shore of Norway is a conclusive answer to the contrary; and numerous instances might be adduced in which the gulf stream has comparatively straight shores, shallow water, and extended diluvial and alluvial plains on its very borders. The southern coast of the Arctic Ocean, on which the gulf stream is driven, is as remarkable for a great extent of depositions, as the coast of Norway, leading from the very same Cape, is for denudation. Material differences in the sum of casualties have occasioned directly opposite effects.

Upon the southern and eastern shores of the Bay of Biscay, tolerably straight lines and deep water prevail. The Bay is open to both the gulf stream and the Atlantic Ocean. Spain on the north differs from Ireland on the west in a main feature. Both are bounded by the two oldest formations. But the former presents the side of its mountain chain to the Bay of Biscay; whilst in the latter a pair of fractured ends face the Atlantic on the south-west, and which would seem to be favourable to the prevalence of natural harbours.

France on the west exhibits a considerable extent of depositions in the Bay of Biscay, accompanied by a straight coast, barred rivers, and deep water at the same time. The Bay of Biscay, being embayed, the tidal wave is consequently driven along its shores, and these peculiarities are the result.

In Britanny the primary formation is extended in the direction of Ushant, and is there brought to an abrupt and rugged termini. Standing prominently forward in the direction of the Atlantic, the action of the tidal wave upon its shores is similar to the south-west of Ireland, and the best class of harbours are accordingly met with. Brest need be named only as an instance. This is the beginning of a class of excellent harbours which face the Atlantic westwards; and through the British Channel command the entrance into the North Sea. Ushant and the Land's End seem to stand forth upon the mighty waters of the west, like peerless and rival giants, destined to shelter and command the maritime and commercial affairs of the eastern world. Not because they are bold headlands merely; but because they are constructed of such materials, in reference to the tide-wave of the Atlantic Ocean, as leads to the scouring out of the best natural harbours, adapted to the improvements which art and science bestow, and in a geographical position, which is the key of the eastern plain, its seas, estuaries, and rivers. What has been said before shows that the tidal pulsations of the Atlantic flow into this great roadstead, the British Channel, and ebb off again. Flowing as these tides do from a deep and pellucid fountain, and coming along deep channels from which drift has been previously driven in lateral courses, the only works required under the most favourable contingencies are landing places and breakwaters. Where nature has offered facilities so complete, human art and science have but to be successfully applied. Portsmouth and Plymouth on the side of England, are balanced by Cherbourg and Brest on the side of France, the watchful guards of their respective frontiers. Harbours so vast and truly excellent are to be found only where geography and geology have equally combined in the concentration of so many perfections.

Milford Haven is another of those roadsteads and harbours in which nature has bountifully contributed to the facility and security of navigation. Capacious, deep in water, and sheltered within iron barriers, the tide-wave of the Atlantic flows on, and ebbs, from this great harbour. It is to the direct action of the ocean, smoothed in its approach, equally flowing and ebbing on right lines free from the disorders of currents and counter-currents, frequently from land in one form, and along shore in another, barring the various inlets swept across, that we stand indebted for the advantages of Milford Haven. A place which may in future claim and gain our national attention deservedly.

The Bristol Channel lying on the same bearings as Milford Haven, has the same requisites of water and tidal action. Hence vessels of great burthen reach stations as far inland as Bristol. In estuaries so extended, the receptacles of vast inland drains, navigation is apt to be impeded by accumulations of drifted silt, which these drains emit, and the termini of a tide-wave deposits. Hence the upper region of this arm of the sea is pestered by sand banks and shallows; yet in a more limited degree than most of our other estuaries, for the reason just stated, its lying in a direct line with the flowing tide-wave of the Atlantic. In the instance before us, therefore, these objections are compensated by the depth of water and the directness of the channel. A tide-wave coming directly from an extended ocean, we also further learn, is less liable to bar inland streams, than embayed channels and seas. The Bristol Channel, besides, possesses a great facility to navigation in an uncommon rise of tides, and which we shall presently discuss more fully.

The origin of a tidal current being seated in the Atlantic Ocean, coming along the south Irish Channel, through the compressed space which lies between Tuscar Rock on the Irish coast, and Saint David's Head on that of Wales; and running with a strong current directly into Cardigan Bay, though Carnarvonshire affords a bold projection on the north thereof, yet the depositions of silt in this bay are trivial. Notwithstanding its being a point on which drift is naturally thrown off in a lateral direction, and more especially on the Welsh coast eastwards. Carnarvon Bay also, placed under like contingencies, and for similar reasons, with an opening through the Menai Strait, is almost entirely denuded, and freed from depositions as old as the tertiary formation. The current propels its drift through the compressed channel of Tuscar and Saint David's Head, therefore, in a direct line with the Solway Frith, and along the eastern shore of the Isle of Man. Before it arrives in the Solway Frith, however, the tide-wave of the north Irish Channel fills the Irish Sea as far southwards as the Isle of Walney in North Lancashire. Consequently, drifted silt is driven on the termini of this lateral tide-wave, and cannot return. Its deposition is therefore evinced in great abundance along the entire line of the Lancashire coast,—from carboniferous limestone to marine alluvian, with bays and rivers almost choked up or beset with sand banks. The estuaries of the Dee, the Mersey, the Ribble, the Lune, and Morecambe Bay, with their outlets on the coast of Lancashire, present as much as 200,000 acres of sand banks, which are either dry or nearly so at low water. Inland, between the rivers Mersey and Lune, corresponding depositions of marine and fluviatile alluvian are found equally remarkable in extent, and contrary to what is exhibited on the coasts of North and South Wales. Further inland, in Cheshire and Lancashire, between the rivers Dee and Lune, an immense and unusual breadth of red sandstone, on a low general level, overlies the western boundary of the coal measures.

Here an assignable area is discovered into which a large portion of the drift connected with the British, the Bristol, Saint George's, and south Irish Channels, has been driven and deposited. Casting the eye over the continuous vallies of the Dee and Weaver into that of the Severn, we are able to account also why so much of the drifted forests of Norway have been stranded and deposited in Lancashire. At the same time tailed off southwards as it would seem, or carried forwards into Flintshire, Staffordshire, Shropshire, Warwickshire, and Wales; since drift carried by oceanic currents on the shores of Lancashire has yet no tendency to be borne out to sea again. The extensive plains of Lancashire and Cheshire, almost the only ones of considerable extent, immediately facing Saint George's Channel and the Irish Sea, that of Whitehaven and Carlisle excepted, is conclusively favourable to the deductions here taken. From Pembroke to Flintshire in Wales, and from Whitehaven to Furness in North Lancashire, the western coast of the kingdom is all but denuded of newer formations than the primary depositions.

Facts so palpable and satisfactory, would appear to place our leading theory on immutable foundations, whatever decisions may await trivial details.

The tide-wave of the north Irish Channel, coming directly from the deeps of the Atlantic Ocean, discloses most or all of the features which belong to the south Irish Channel just treated upon. Bold and forked capes, like those of Moile, Cantire, and Galloway. Deeply indented bays, admirably suited for navigation and marine security, like those of Loch Ryan, the Frith of Clyde, and Belfast Loch. Harbours like Lamlash, and anchorage like that of its roadstead. Rivers choked up by sand are by no means discovered here, as in those of Cheshire and Lancashire. The depth of water in this fine channel is mostly uniform, and in the current seldom below 60 fathoms, and often 20 or 25 fathoms close in shore. Here are no sand banks at all. The majestic current has borne them forwards into the Irish Sea. On the shore of Ireland, southwards, the water is generally of considerable depth up to Dundrum Bay. The current flowing along shore, however, has barred all the harbours on this line either more or less; whilst the main portion of drift has been propelled in an eastern direction, and undergone deposition on the southern and eastern shores of the Solway Frith. Depositions are again in this instance borne from the commencement of a tide-wave to its terminus. The direction of Whitestone and Bahama Banks, from off the point of Ayr, the north-east headland on the Isle of Man, as well as King William's Bank, go to show that a current starts there in the direction of the Isle of Walney. A southern current from the north Irish Channel, therefore, as well as a northern current from the south Irish Channel meet on the Isle of Walney, and equally contribute to propel drift on the coasts of Lancashire, which has no tendency to return. The flowing tide running quicker than the ebb.

The figure of the Isle of Walney owes its peculiar form to the meeting of the north and south tides thereon. In strong and prevailing northerly winds, a powerful current sets around the south horn of the island, drives beds of shingle in advance, bends the extreme point of the island inwards, and slightly bars the entrance into Pile of Fowdry. In proof that strong northerly gales have this effect, large stones previously lying on the western shores of the island, or seawards, have been swept around the south horn and left on the opposite or eastern side of the island, as much as three miles distant from where they previously lay. The excellent roadstead close on Roe Island may be attributed to tidal action being thrown into eddies by Pile and Foulney Isles. When southern gales are strong, a tidal current flows northwards, which bends the northern extremity of the island inwards, the same as its southern extremity. These are the effects of the tide-waves of both the south and north Irish Channels meeting on the Isle of Walney, and discharging and depositing drifted silt upon the Lancashire coast as already stated.

The Solway branch of the north Channel is, however, that into which the main portion of its drifted silt is thrown; and for the reason already assigned it is chiefly deposited on the Cumberland shore of the Solway Frith. A striking instance is here displayed of the nature of tidal action and deposition. The Low Holm is a tract formed of marine and fluviatile alluvian, deposited on the southern shore of the Solway Frith, angular in its figure, and as much as 10,000 acres of land in extent; bounded on its southern edge for about 10 miles in length by diluvial beds of clay and sand. On the north-east, where this plain is three miles across, Kirkbride Loch is situated, about 4500 acres in extent, and through which the rivers Wampool and Waver empty themselves into the Solway Frith. The western line of this alluvial plain is immediately bounded by the Solway Frith, from Bankend near Maryport, to Grun Point north-east of Skinburness, for 12 miles in length. As a flux tide upwards, has twice the speed of a reflux tide downwards, commencing at Bankend, a travelling bed of shingle has been driven before the tide as far as Grun Point, and which has effectually embanked 10,000 acres of land from the sea. No work of art could have been more complete; and a lesson is given on the science of silting up and reclaiming estuaries from the ravages of the sea. By copying after nature we are taught sound principles of art on purely physical laws. This embankment is wholly constructed of shingle, from 100 to 300 yards in breadth, and about 10 or 15 feet above the level of ordinary spring tides. Drifted sand has contributed to heighten the embankment along its whole line; and in some parts it has been blown up into ridges as much as 40 feet in height, and matted over with marine plants, which augment its efficiency and strength. Immediately within this marine embankment, the land lies on a low level, is free from stones, and affords at the same time a natural and protected drain to the more inland parts of the plain. Previous to its termination at Grun Point, for four miles in length, within which the chief portion of the plain lies, a small brook runs immediately along the ridge of shingle, having a short sea-dike across at Skinburness that protects one of the most fruitful tracts of land in the county of Cumberland. In the Low Holm as much as 9000 acres of land has been formed within this marine dyke, perfectly secure and free from inundations. From Bankend to Grun Point there is not the slightest appearance of a breach being even threatened at any period of time. But it is on record that a remarkably high tide swept the village of Skinburness from off the crest of the marine dyke on which it stands.

A feature in the quality of the soil of Low Holm is, that the tide-wave has drifted sand and finely divided clay around the end of the travelling beach just described. This operation has in fact assorted the materials of which the soil is composed. Sand has been the first deposited and driven the furthest from the marine dike. Finely divided clay being more buoyant and adhesive has been thrown uppermost, and in the greatest abundance immediately within the line of the dike. Physical laws have, therefore, provided a highly fruitful soil by a favourable (almost intelligent) assortment of the materials of which the plain is composed. Trivial as this may seem in passing, the simplicity of nature's handy works is evinced, a wise and providential economy has been exercised, and we are left the especial task of drawing our knowledge from facts. It is proved that the most judicious mode of reclaiming land from the sea, is not only putting nature into a true form that she may work for herself, but according to her best and most effective laws. By such means the land reclaimed may be rendered fruitful in quality, in place of almost barren silicious soils gained at a heavy expense; opposed to cheap and effective plans, which acquire the best land by taking a copy from nature.

The rivers Wampool and Waver, two small inland streams, have checked the further progress of the marine dike at Grun Point, and disturbed the navigation of the Solway Frith exceedingly. But for this incident, the dike of shingle would have assuredly gone on two miles further, rested its termini on high and strong ground, and reclaimed an additional 4500 acres of the best land from the sea in Kirkbride Loch. This land being mostly dry at low water, and not more than one half its area covered by neap tides, we shall consider its means of reclamation by and by.

Viewing the estuary of the Solway Frith as a whole, it is more than one-half choked up by drifted sands, brought forwards by inland drains on one hand, and returned again to a tidal terminus on the other. From Maryport to Sandsfield, the beginning and the end of the Solway, there is an almost continuous tendency to the deposition of silt upon the coast of Cumberland. With the exception of Bowness indeed, which stands out boldly northwards and presses upon the red sandstone of the Scottish coast, by the force of the figure of the estuary, for diluvial beds press here upon rocks, the entire line is favourable to the gathering of depositions, and constitute the main cause of the travelling beach already described. The line of the shore from Bankend to Sandsfield, corresponding to the zone of limestone and coal measures southwards, is in truth a regular curve, with a breadth of two miles intervening, through which the Wampool and the Waver flow from the uplands. Descending step by step from carboniferous limestone, high above the level of the sea, transversely across coal measures and diluvial beds, until they reach the Solway, and effect a breach in the natural deposition of its alluvian, to the extent of 4500 acres within Grun Point, not to say how much they check depositions in accumulating seawards. Estimating the Solway Frith from Maryport, as much as 100,000 acres of sand banks are either dry at low water, or nearly so. Such a waste of British territory, and so much detriment to navigation on the narrowest point of England, deserve intense public notice, since a highly profitable remedy is available.

What has been previously said throws much light upon the general features of the tide-wave in the North Sea. Like those of the north and south Irish Channels, it springs from the deep heavings and mighty pulsations of the Atlantic Ocean. Borne along the mountain chain of Norway, from the very character of the position from whence it starts, and pent up by land and counter currents southwards and westwards, we need observe only that it is beset with sand banks, which endanger navigation, that its bays are choked up by drifting sands; that its rivers are barred; and that its most favourable backwater navigations are merely tidal. How unlike Valentia, Bear Harbour, Cork, Milford Haven, Brest, Cherbourg, Plymouth, and Portsmouth, all lying in one continuous and short line! Whatever drift is carried into the North Sea can never return; whilst a strong tidal current runs along and never from its shores on north and south bearings. In reference to this incident, on the British shore, all the rivers run from west to east. Consequently, the tide-wave uniformly crosses and bars every inland stream, drifts up every bay, and imparts a deadly hindrance to navigation.

England, however, enjoys an ample compensation for these defects, in the extent of land she has thereby acquired, and the amazing sum of drifted forests which have been stranded and deposited in the tertiary formation. Along the eastern line of Great Britain, we detect in the efflux of every river, as shewn by any tolerably good chart, the plainest evidences of a strong current flowing along shore from north to south, as the openings of almost every river is driven southwards by tidal action. The prevailing straight lines, indeed, along this coast, as compared to the western shores of Scotland and Ireland, and the general shallowness of water in shore, from the Frith of Forth to Dover, prove the direction and vastness of the drift, scoured from Polar deeps, and deposited on points of land, where it remained eternally at rest. As concerns navigation, therefore, bad is continually becoming worse. Amendment by any operations in nature is hopeless. Art is nevertheless profitably available.

At Banff we meet with an instance of inland backwater, ever contending with the sea in a struggle for mastery. Sometimes the inland torrents for the river Doveràn sweep off a bar, which occasionally precludes navigation almost wholly. No sooner is this effected than a cross tidal current, probably recommences the formation of a bar, at the entrance of the river Doveran into the Murray Frith, composed of shingle and sand.

A deeply indented and extensive bay is certainly met with in the Frith of Forth, owing to its relative bearings on Norway. Yet how unlike Bantry Bay on the south of Ireland, or navigation around the Isle of Arran on the west of Scotland? Its waters are mainly shallow, and adverse to those high promises so fine a piece of water at first sight holds out.

At Blyth, in Northumberland, even tertiary depositions take a southern bearing, which might in so much have given a well sheltered harbour. Yet a cross tidal current running southwards has rendered it a dry harbour for vessels light in draught of water only.

In the river Tyne a heavy backwater and bold promontory are met with, where Tynemouth Castle peers above the watery waste. Immediately within the southern shelter of this natural bulwark a deep pool is scoured out by a reflected eddy coming off the Herd sand. Yet in a line southwards from the promontory of Tynemouth, the force of a cross current deposits a dangerous bar, though 25 fathom of water is found immediately seawards, and touching the very edge of the bar. Here retracing as we are the former disquisitions of this work, the same action of a southern current in the North Sea, in barring the entrance into the river Tyne, is precisely similar to that which deposited the coal formation of Northumberland and Durham, fixed the range of magnesian limestone, joined together the primary Isles of England and Wales by red sandstone, and formed the south-east section of England. A mere ridge of sand, replaced and protected by the flowing tide, is adequate to check the waters of the river Tyne and the tidal scour also. A more palpable instance of the effects of cross currents could not be given.

Hartlepool is obviously a projection of the same tidal law that applies to the Tynemouth promontory. A vacant space being left inland, that space has been most scientifically converted into a tidal scour, which in some measure promises a secure place of refuge where it was exceedingly desirable. A little further south only, on the coast of Durham, the embouchure of the Tees is choked by accumulations of drifted silt, which the headland of Hartlepool contributes to aggravate. The difference between a tide-wave flowing upon a harbour at right lines, as illustrated by Milford Haven, and across, as on the efflux of the Tees, is obvious.

Whitby, possessing an inland backwater, is similar to the Tyne; and Scarborough, divested of backwater, resembles the effects produced at Hartlepool. From the Frith of Forth to Spurn Head, the North Sea affords a fine navigation along its western shore. This may be in some measure attributed to an easy sweep of the coast, in conjunction with numerous and powerful inland streams, which are mainly protected up to the line of shore by rocky bulwarks. Have these inland drains denuded and preserved the beds on which they run?

Spurn Head accords with our general theory most fully. Its projection southwards shows that such an incident has not proved injurious, but beneficial to navigation. Especially as Spurn Head has somewhat the effect of an island, which turns the tidal current into eddies that equally preserve a flow of water on all points.

In the Wash, we observe the influence of considerable inland drains preserving a large breadth of water, which a southern flow of the tide-wave has choked with silt. Gibraltar point conforms to the rest of the headlands previously noticed on this shore. Gore point also, on the Norfolk coast, is turned southwards.

At Yarmouth a striking instance occurs of the sea driving a travelling beach before a flowing tide, and reclaiming a large tract of land from the sea by natural means. As the original seat of the tide-wave of the North Sea is in the Atlantic, so is it likely to perpetuate those effective barriers, which have been raised by natural causes, as in the Low Holm on the shores of the Solway Frith.

At Harwich also, Landguard Point is driven southwards, in the face of the river Stour, and open water lying further southwards, Harwich enjoys a deep pool easy of access. An instance is here presented of a form in which a cross current has not barred an inland stream. As the coast of Essex trends south-west, and as the mouth of the Stour is within the influence of the river Thames, the river and tide take the same line of current, and Harwich has consequently a good harbour easily entered. Besides, the considerable area of water in Holbrook Bay and the channel of the Stour inland, operate as a powerful scour in the preservation of deep water from Harwich to Landguard Point.

The river Thames enjoys a tidal navigation worthy of a continent. Flowing on an alluvial bed from Windsor to Gravesend, limited to a contracted channel at Gravesend and Tilbury, by strong ground on both sides of the river, and possessing a necessary weight of water, that water is effectually compressed without becoming shallow, or beset by critical and dangerous sand banks. The Severn, the Humber, and the Mersey, are each of them defective in these combined advantages. In want of strong ground in advance to compress its waters, the Severn merges into a long and wide channel, and the Humber has a similar defect. If the Mersey be tolerably compressed, with a large body of water flowing upwards and into an enlarged area of the river in the direction of Frodsham, which acts as a powerful scour on Liverpool, the Mersey is nevertheless deficient in weight of water, which evens, deepens, and secures the canal-like navigation of the Thames; and when its waters fall into the North Sea, united with the Medway, unfettered by rocks, and powerful enough to correct the obstructions of a bar, a good and regular depth of water is constantly preserved. The estuary of the Nore is certainly pestered by sand banks, which are a material hindrance. Yet, buoyed and beaconed as this ground is, the danger is exceedingly mitigated; and the river Thames, flowing so much, so evenly, and deeply inland, is worthy of England. On the bosom of this broad inland canal, her true greatness is verified. Busy industry ever cheers the scene; and marine affairs are carried on in resemblance to some mighty highway, where every species of craft is passing and repassing in ceaseless activity; coming from or bound to every clime on the habitable globe, as if craft of every description were but names for so many carriages going to and returning from some great mart.

In tracing the line of coast from Tilbury to Harwich, the fidelity of fluid action is well illustrated. The southwards current of the North Sea, thrown off at Harwich by the south-west trending of the

Essex coast, the prevailing set of the current is completely reversed by the relative spaces this vacancy brings into juxta position in connexion with land streams. Canvey Island, Foulness, Stone Point, and the site on which Harwich stands, together with the general line of shore, evince a prevailing north-east current. The sand banks of the Nore uniformly take a consimilar course. Running off with the north and south line of Southwould and Orfordness. But the Goodwin Sands, the little Bank, and Calais Bank, off Dover and Margate, assume the north and south range of the North Sea, and conform to its general current. Nor is it a little remarkable that these several sand banks lie immediately on the entrance to the Strait of Dover. Why? In the north Irish Channel nothing similar is found, because it is a tidal thoroughfare. Here a counteracting tide-wave obtains.

The tidal currents of the North Sea and the British Channel meet in the Strait of Dover, and repel, and have repelled each other on this ground now and formerly. The balance of prevailing winds may incidentally shift the contact of these tide-waves, westwards or eastwards, but the Strait of Dover is the true central point on which they balance each other. Romney Marsh is also a deposit attributable to this tidal meeting; and a balance of currents is contributing to close up, and not enlarge the Strait of Dover, where we might have expected that rocks themselves would scarcely hold their place. Even the chalk hills of Kent, Sussex, Surrey, and Essex, are all of them depositions, and consequences of the same balance and terminus of currents. In the north Irish Channel no sand banks, rocks completely denuded, and eighty-eight fathoms of water in the centre of the Channel, are met with At the Strait of Dover thirty fathoms is the deepest water met with, the most shallow line of water between Great Britain and foreign shores. All drifted silt which enters the North Sea necessarily remains there, and contributes to obstruct navigation. In truth, the Strait of Dover has a natural tendency to silt up, may possibly do so in time, and such an event happening there would be no likelihood of its breaking down again. For it is what has previously occurred in the basins of London and Paris, each of which lies in the same line of oceanic contact. The reason why France and England are brought so near each other at the Strait of Dover, is owing to depositions from the coast of Norway and the south of Ireland being driven here and remaining. Why do we find Romney Marsh? Why are dry sand banks found at ebb-tide all but in the Strait of Dover? Why is 30 fathoms of water only exhibited in the southern parts of the North Sea? What a contrast to the coast of Norway! As much as 200 fathoms prevail close in shore. Conclusive facts evince the truth of what has been said before.

The North Sea is but a point to which depositions, which lie extended 2000 miles eastwards, and 1500 in breadth, have arrived. The very Atlantic and Polar deeps have been scoured out to find material for a territory so enlarged. In short, to this hour, the very rocks of Norway are daily ground away, and the silt so produced is driven into the North Sea, or deposited on its shores ever to remain. We shall now proceed to the application of these premises.

In closing the chapter before us, however, it may be observed that a shelving beach is a usual form of the shores of the sea. Hence the ordinary position of stratified rocks is that of a slope carried out to its extreme angle. On such grounds Mr. Fairholme justly infers that projecting cliffs have had their original elongation cut away by the action of the sea in cross currents. On this head the student in Geology may obtain much satisfactory information from his work on the Mosaic Deluge.

CHAPTER V.

ON THE IMPROVEMENT OF NAVIGATION; THE CONSTRUCTION OF BETTER HARBOURS; AND THE RECLAMATION OF LAND FROM THE SEA, IN REFERENCE TO THE BRITISH ISLES.

The rise of tides upon our shores is here a primary consideration. The North Sea, the Irish Sea, the British, Bristol, and Saint George's Channels, having no rise of tides intrinsically within themselves, derive their tidal phenomena from the Atlantic Ocean. Thrown off by the returning gulf stream in its southern course, these tides are necessarily regulated by one common impetus and volume of water. Every difference in tidal elevations witnessed on our shores, must therefore be sought for in other causes than the primary tide, which may be taken as equal in the distribution of its waters.

Lunar influence acting by the force of gravitation on the body of water contained in the Atlantic, being the original seat of tides on the shores of the British Isles, and the north of France, the flow and ebb of those mighty waters, though we have assigned them nine feet in spring tides, and six feet in neap tides, at the Blaskets, yet the flow and ebb of the Atlantic itself may not exceed three feet in spring, and two feet in neap tides. Whether lunar influence withdraws or augments the force of gravitation on a body of waters so extended and deep as these are known to be, an elastic bound so mighty in the depth of impulse, naturally imparts a higher tidal elevation proportionally as it runs on shallow and limited shores. At the Blasket Island, therefore, on the west coast of Ireland, the ordinary rise of spring tides is 9 feet, in Bantry Bay 11 feet, and Youghall the same, at Waterford 13 feet, and in the Irish Sea 20 feet. In the north Irish Channel the rise of spring tides is 11 feet, at Belfast the same, and in the northern section of the Irish Sea 26 feet. But in the Pile of Fowdry, where the tides of the north and south Irish Channels meet, the rise of tides is 30 feet. Tracing the tidal rise in the British Channel, beginning at the Blasket Island it is 9 feet, in Bantry Bay 11 feet, Falmouth 18, Eddystone Light House 18, Sturt Point 20, Yarmouth 12, West Cows 15, Southampton 18, Spithead 18, Selsey 15, Brighthemlstone 16, Beachy Head 20, Dunge Ness 24, and Folkstone 22 feet. On the coast of France, opposite to Falmouth, the rise of tide is 20 feet at Ushant, Isle de Bas, 27, Morlaix 30, Isles of Brehat 36, Cherbourg 20, La Hogue 16, and at Havre de Grace 23 feet. In tracing the tidal rise from the Blaskets, up the Bristol Channel, at Cape Cornwall, it is 22 feet, Saint Ives 24, Padstow 24, Lundy Isle 30, Barnstable Bay, 30, Mine Head 36, Flat Holm's 36, and King's Road 42 feet. In Milford Haven, the rise of tides is 36 feet. As a general theory, the sum of this data shews that the impulse of the tide-wave from the Atlantic Ocean, rises proportionally in elevation as it flows on shallower beds, and along more compressed channels and estuaries. From the Blaskets its rise progressively increases from 9 to 13 feet at Waterford. The rise from the north Irish Channel to the Solway Frith is 11 to 26 feet; and to the Pile of Fowdry 30 feet. From the Blaskets to Dunge Ness 9 to 24 feet, with undulations intervening. On the French shore of the British Channel the rise is 9 to 36 feet at the Isles of Brehat, alternately undulating up to Dunge Ness, where the streams of the North Sea and the British Channel usually meet, yet not the point on which the contact bar rests, which is directly in the Strait of Dover. From the Blaskets to King's Road in the Bristol Channel the tidal rise is progressively from 9 to 42 feet.

However liable to exceptions these facts may appear, yet a fair balance of incidents equally confirm the general theory. The original seat of the tide-wave of those respective seas, channels, and estuaries, can be discovered in the Atlantic Ocean only; and the rest must be attributed to the configuration of the land, and the depth of the water, along and over which that tide-wave flows. The primary impetus given is precisely the same. Contingencies form the cause of exceptions to a general rule, yet that rule is by no means less certain, though disturbed and broken by irregular action in detail. The differences in tidal rise, therefore, must be sought for in local bearings, and each case receiving a separate examination.

Sufficient facts are adduced to show that the difference of tidal elevation is a plain question, in which first causes must be traced to final consequences. If Milford Haven be favoured with deep water, owing to tidal action taking a right line from the westwards in place of the eastwards, as on Bantry Bay, it also possesses a powerful scour in enjoying a tidal rise of 36 feet; and the same arguments equally apply to the Bristol Channel in general, where the rise of tide is still higher. What has been said of Bantry Bay is certainly at variance with the inference here taken, as the tide rises less in the Bay, and more in the Haven, and the Bay is, nevertheless, smoother and deeper in water. The real case may stand thus. In a direct pulsation communicated by a fluent body so mighty as the Atlantic Ocean, a scour is produced which sweeps away every accumulation of drift unobserved. Not to say how much this scour is augmented by the eastwards motion of the earth, and the westwards current of its waters. Hence, those havens which lie on the south-west of Ireland, between the river Shannon and Cape Clear, possess unrivalled advantages. Brest holds a position much the same as Milford Haven; and it enjoys equal depth of water and natural security. But the rule is nevertheless fettered with exceptions the further we ascend the British Channel. Portsmouth lying more remotely from the Atlantic, is less favourably situated, in that respect, than Milford Haven and Brest. For we find the depth of water diminishing in the British Channel itself to 9 fathoms in most parts of the Strait of Dover, because the tidal wave has here arrived at its termini. If Portsmouth lose some of those advantages partly which the two latter enjoy, it is fully compensated by the position of the Isle of Wight, owing to the scour and shelter afforded in the roadstead of Torbay.

In following out the order of facts, therefore, and taking those inferences which cannot be mistaken, the theory previously entertained on the deposition of the chalk formation of Sussex, Surrey, and Kent, are remarkably confirmed. For the bar across the Strait of Dover is itself a ridge equal in comparative elevation to those of the chalk formation inland, in reference to the level of the North Sea and British Channel; and we may be again allowed to notice these Geological analogies in passing.

The data already given directly explain the excess of tidal elevation in the Bristol Channel. If Ushant be taken at 110 miles distance from Land's End, and if from Cape Cornwall to the Isle of Scomer be also 110 miles, the British and Bristol Channels present two forked like figures to the flowing tide-wave of the Atlantic Ocean, equal in stride, but differing materially in area. The solid contents of water flowing from the Atlantic on each of these channels is equal, therefore, yet the area of the British Channel is nearly triple the extent of the Bristol Channel, and deeper in water also. As a tide-wave runs into Cardigan Bay, and as far as Pile of Fowdry, so an equal body of water, on these terms, is driven into the Bristol as into the British Channel. Being shallower in water, and one-third of the area only, the cause why the tidal rise at King's Road is 42 feet, and at Spithead 18 feet, is plainly accounted for. The rise of tide is high in the Bristol Channel, owing to a large body of water being propelled upon a compressed area; and if the rise of tide at King's Road be not triple that of Spithead, re-action may in some measure be said to check the flow of the tide up the Bristol Channel.

Nor is there any law of fluidity more satisfactorily illustrated by facts than the dependence of tidal elevation on the figure of the land around which it flows. At Poole, a major and a minor tide prevail. The returning tide, through Christ

Church Bay, sets into Poole a second time in each flow, and occasions a double tide. At Havre also, on the coast of France, the tide does not perceptibly ebb, until three hours after high water. In consequence of this peculiarity, fleets of 120 sail are able to leave the port in a single tide, though an adverse wind were against them; and so variable is the rise of tides locally, that a difference is the rule rather than the exception. For if the original heave of the tide-wave be a swell of less than two feet within the bosom of the Atlantic, the impetus given to this mighty body of water, conjoined with local incidents, raises the tide at King's Road 42 feet, and at Chepstow still more. The primary pulsation of the Atlantic, therefore, elevates the tide-wave subsequently according to local bearings and geographical figures.

In the sum of these facts we learn the true cause why drift continues to accumulate enormously on particular localities along our shores, and obstruct our navigation. Foremost in this class of injuries to our marine safety and facilities stand the Lancashire and Cheshire coasts, the Wash, the estuary of the Thames, and that of the Solway Frith. These embrace the main points on our shores where tidal drift has a decided tendency to deposition, and proves highly detrimental in consequence. We shall therefore proceed to treat each instance in itself.

The different estuaries on the coasts of Lancashire and Cheshire may be estimated at 200,000 acres in extent. Namely,

In the Dee	36,000 acres.
— Mersey . .	27,000 do.
— Ribble . .	28,000 do.
In Morecambe Bay	96,000 do.
In the Duddon . .	13,000 do.
Total .	200,000 acres.

As the eastern termination of the tide-wave of the Irish Sea is directly upon this line of coast, from both the north and south Irish Channels, on the theory of depositions already given, and divested of especial counteracting causes, we might here expect an advance of alluvial deposits on the face of older formations westwards, without a single instance to the contrary occurring, or the semblance of a good natural harbour appearing on the entire line of coast described. Estuaries are nevertheless found to the extent of 200,000 acres, amidst a space of alluvial deposits which conform to the theory propounded. In each of these exceptions to the rule laid down, the weight and force of inland backwater satisfactorily account for the carrying off of marine silt, which might have otherwise been deposited. The rivers Dee, Mersey, and Ribble, attest the correctness of this conclusion. The embouchures of these streams, in emptying themselves into the Irish Sea, have carried off 91,000 acres, on which marine drift might have been deposited and land been formed. In Morecambe Bay also 96,000 acres are found denuded of land, by the rivers Lune, Ken, and Leven, which, with their tributary streams, are probably equal in weight to the Dee, Mersey, and Ribble. No doubt similar causes of denudation have been carried to equal extent; and Morecambe Bay is not more extensive than inland backwater has occasioned. In the minor stream of the Duddon 13,000 acres of estuary only are found. Hence a conclusion may be taken that the spaces occupied by each and all of these estuaries have been scoured off by the respective inland drains which flow through them. Any diversion of these rivers, or their compression by wearing that secured them within more limited and fixed channels, would lead to the speedy silting up of the extensive estuaries found on the coasts of Lancashire and Cheshire, as the whole extent of this 200,000 acres of estuaries may be attributed to similar causes producing similar results, and Morecambe Bay is not more enlarged than the extent of backwater it contains.

What are the means of diverting and wearing the various land streams, would seem the next question to be answered? Any material diversion of the rivers Dee, Mersey, and Ribble, would evidently appear inconsistent with the character of these respective streams. Wearing, however, seems applicable in the first place; and when given advantages were thereby gained, embankment might securely follow at an available expense. Dealing in general principles, however, rather than especial details, it may be enough to say that powerful jetties ought to be thrown judiciously out on the lower or western extremities of those estuaries. Be it observed, the true set of a prevailing current is not along with, but against the courses of these respective rivers. Since the flow of the tide into an empty space is necessarily more rapid and powerful, than either its ebb or the temporary influence of land floods. This fact is of considerable moment. The neglect of a consideration so vital would be sure in leading to errors and disappointments. Besides, any works successfully undertaken on the lower parts of the Dee, the Mersey, and the Ribble, would be sure to increase the effective scour of those rivers, narrow their breadth, deepen their channels, and materially improve, facilitate, and secure the course of navigation. All experience shows that depositions of shingle mostly go along with and not against the flowing tide, as the current is commonly more rapid and stronger during the flowing than the ebbing tide. Every shore on the British Isles attests the frequency not the constancy of this tidal law. Yet engineers have failed in bestowing due attention on, and availing themselves of a powerful instrument by which land may be securely gained from the sea, through the aid of tidal power, and the channels of navigation undergo material improvement in depth of water and evenness of course. Why is the navigation of the Thames so favourable? Because running through weak ground inland, and compressed at Tilbury Fort and Gravesend by strong ground on both sides of the river, it has shaped out for itself that even channel for which it is pre-eminent. On similar laws a marine dike, like that of the Low Holm on the shore of the Solway Frith, projected on Formby Point, travelling continuously eastwards, or in the direction of Liverpool, would augment the scour of the Mersey, deepen its sea channel, and sweep off those sand banks which impede and endanger its navigation so materially in its present form. A few inland streams that continually disturb the channel by cross currents and restless sands, found on the shore between Formby Point and Liverpool, would by the application of such means assume an eastern course, cease to disturb the channel, and deposit broken and shifting sand banks. For the balance of the upwards current exceeding in strength the downwards one, so the projection of a travelling beach, might not only reclaim a large area of land from the sea, deepen the channel materially, steady its navigation, and facilitate in the mean time the ease thereof; but probably lead to the formation of a place of refuge, having sufficient water at all times of the tide. Such an acquisition in the vicinity of Liverpool would be invaluable. Indeed, as applicable to the instance before us, nature having expounded her own laws, we have but to follow her dictates to come at sound conclusions, and fabricate works on plain and effective principles. While engineers continue to mistake the balance of currents, and treat them as flowing in the opposite direction to the true one, little or no good can be effected. Let such a defect be fairly obviated, however, right principles might speedily lead to a correct application, and wonderful results follow. Converting those very rivers and streamlets that now disturb the channels of navigation so destructively, into the means of acquiring secure places of refuge at all times of the tide.

The river Wye may be in some measure an instance of this sort. It has originally run directly into the Irish Sea. Driven northwards by the superior weight and force of a southern current, a natural scour has been finally produced behind Ropal Point, which now excites the attention and hopes of an enterprising company. With an instance so evident before us, it would appear that much might be accomplished in the channels of the Mersey, and still more in that of the Ribble, now infested with lateral streams, and choked up by drifted sands. It must in passing be admitted, that the Ribble, compared to the river Mersey, is deficient in the weight and force of backwater. The powerful scour, moreover, brought upon the river at

Liverpool by the swelling expanse of water which lies in the direction of Frodsham, must also be taken into account. Still, it may be meanwhile admitted that every deposition of those sands which now choke up the navigation of the Lancashire coast so injuriously, might be converted into beneficial purposes, providing the material also of which reclamations of land are composed. Were the river Douglas and other minor streams, that fall into the estuary of the Ribble, driven eastwards by wearing, a travelling beach might be established, the breadth of sand compressed, the reclamation of a large extent of land effected, and the Ribble gain an excellent navigable channel. Were a line of beach sprung from Lytham on the north, from Stockport on the south, and eastwards by jetties kept low, they would be sure in some measure to attain the objects desired.

Having said thus much on the estuaries of the Mersey and the Ribble, it need be remarked on the Dee only that the embankment company there formed have commenced their works at the wrong end. Instead of co-operating with the tidal action of the estuary, they work against it, and in some measure fail in reaping the highest results attainable to both navigation and themselves. In place of amending the navigable channel, which, by starting at the point of Air on the south, and at Little Meoles on the north, they would have been sure to do, as well as gaining the most land, their unskilful proceedings have ruined Chester as a port.

If the application of such works to the estuaries of the Dee, the Mersey, and the Ribble, as those here proposed, contributed to break up, absorb, and deposit, in a new form, the material of the vast sand banks with which they are infested, the reclamation and silting up of Morecambe Bay, might contribute to the furtherance of a like purpose much more effectively. We shall, therefore, bring under review the incidents which belong to this great bay, and frame practicable plans accordingly.

On the southern shores of the bay, the rivers Keer, Lune, Docker, Cocker, and Wyre empty themselves into this arm of the Irish Sea. In the centre of the bay the combined streams of the Ken, the Belo, the Underbarrow, and Winister, along with minor streamlets, are constantly denuding the bay of all formation of land. Whilst along its northern shore, the Leven, the Cart, the Crake, and the Ulverstone river, with their several tributaries, have stript off alluvial depositions, and scoured out Pile of Fowdry. This united body of water unquestionably exceeds the inland streams of the estuaries of the Dee, the Mersey, and the Ribble; and accounts for the cause of the extent of Morecambe Bay on ordinary physical laws evinced by facts. A conversion of the powerful agents of denudation, into instruments of the formation and reclamation of land, are obviously the first objects that claim attention.

Means of diverting the great central stream of the Bay to either of its sides, and finally carrying the body of water to the verge of the Irish Sea, would evidently convert those waters into the instrument required. So placed, their volume and force would then contribute to break a powerful flux in the Irish Sea, and leave no cause of return to the vast masses of silt which the flowing tide propels into the area of the bay; but which the central stream is continually forcing out to sea again. In the course of two years depositions have been known to form on an area as much as 20 square miles in extent, and from five to eight feet in depth, even under the sweeping influence of this great central stream ofbackwater, which we should purpose carrying on the northern line of the bay, or more full consideration might decide in turning it southwards into the river Lune. It may be asked, indeed, why not embank the sea at once? We should answer that such a work would seem impracticable; and if it were practicable, a vast extent of low lying and almost worthless silicious beds would not repay the cost of embankment so well as reclaimed land silted over on right principles; an objection which silting up fully answers.

Nature seems to have provided art with ample means for either carrying the waters of the central stream into that of the Leven on the west, or into the Lune on the south. At Leven's Hall the Ken runs on a high bed, where it empties itself into Morecambe Bay, 25 miles distant from what may be properly called the Irish Sea. Between Leven's Hall and Castle Head, a distance of six miles, a tract of low lying peat moss is found, situated close upon the northern border of Milnthrope sands. Through this mossy tract a new channel for the Ken might be cut at a light expense, which would so far drain off the central current, except the river Keer, some miles southwards.

On the northern line of the estuary, Grange rocks commence in succession to Castle Head, and occupy a space of three miles. Here the works required would become more expensive, and demand engineering ability, but not attended by engineering uncertainties, in attaining the object desired at an effective and comparatively low amount of expenditure. As a question of impracticability cannot be for a moment stated, we shall, therefore, submit the following scheme of conducting this portion of the works, subject to all those careful and necessary revisions which carrying such works into practical effect call for.

By cross wearing, we should propose, in the first place, to drive the channel of the Ken on the southern shore of Milnthrope sands, or from Grange rocks on Arnside Point; and push forwards the channel of the Winister, temporarily, in the same direction. In the neighbourhood of Castle Head, an embankment for eventually securing the channel of the Ken, on the foot of Grange and Allithwaite rocks, might rest on strong ground; and accordingly as the works proceeded westwards, Holm Island might be rendered available also. Humphrey Head stands on the western extremity of this portion of the ground, between which and Wraysholme Tor, a vale intervenes, through which a new channel might be carried in the direction of Chapel Island, a rock in the channel of the Leven, the terminus of these works, 4 miles distant from Wraysholme, and 13 miles from Leven's Hall, the commencement of the operations. The Grange and Allithwaite rocks, therefore, occupy a space of three miles in length.

In this portion of the works, between Holm Island and Humphrey Head, we should propose a line of wearing resting on these termini, 300 yards distant from Grange and Allithwaite rocks, with cross wearing at intervals, resting on the base line, taking a direction from north to south, throwing the waters of the Ken southwards in the meantime, facilitating the formation of an embankment, and finally carrying the waters of the Ken along the enclosed area at the foot of Grange and Allithwaite rocks. Such preparative steps might be expected to speedily throw a considerable body of silt on the base of these rocks, when an embankment might be cheaply and securely constructed from Holm Island to Humphrey Head. Moreover, as these termini would afford an abundance of stone, as well as the rocks of Grange and Allithwaite, the embankment might be completed in the most effective manner; the Ken and its tributary streams carried through the vale of Wraysholme, and no longer obstruct the accumulation of drift on the central parts of Morecambe Bay.

Between Wraysholme and Chapel Island would be an affair of ordinary embankment. For a mile to the eastward of that island, the construction of works would not be precarious, though somewhat expensive. On the rest of this portion of the line available incidents are uncommonly favourable.

The cost of the entire works, from Leven's Hall to Chapel Island, may be estimated at £65,000, or £5000 per mile, exclusive of the purchase of land, which may be taken at a low estimate. The sum of £78,000, or £6000 per mile, may complete the diversion of the central stream of the bay, and unite it with the waters of the Leven on the western side of Chapel Island, a firm and durable rock.

As these works would effectually clear away the central stream, except the Keer, which might be taken into the Lune at Lancaster for the sum o £10,000, in the course of a very few years, as much as from 20 to 30,000 acres of sand might be expected to exhibit self-reclamation, and might be then embanked, in portions, at a trivial expense to the extent of a green sward appearing.

Sandy materials being naturally the first deposited, and finer and lighter materials being borne further on land, so they remain on the surface, where self-reclamation is adopted, and form a fruitful super-soil. Hence, fine and fertile particles, which vast inland drains are constantly driving into Morecambe Bay, would be assorted from barren ones, by a tidal process, and undergo deposition the uppermost. In all alluvial tracts of country, this law of deposition is manifest, and is a reason why alluvian affords so much fertile land. Mere sands embanked and reclaimed at once, can seldom afford land of much value. If a diversion of rivers, therefore, and awaiting the future deposition of a fruitful soil, appears remote and tedious in its operation, which we by no means admit, the land reclaimed may be estimated at triple the value, gained at one-third the outlay of capital, and at one-third the risk of disappointment, as the chances of failure are high, where powerful and precarious works are undertaken. On the contrary, the process of reclamation here proposed being devoid of risk, and sure in returning a high rate of profits, so it claims a decided preference. As the flowing tide would be converted into a powerful instrument for the deposition of fertile land, which inland streams no longer disturbed, and as the extensive shallows found on the coasts of Lancashire, might afford an adequate supply of materials, so the gains contemplated are quite attainable.

We shall next consider the mode in which the two great side streams, on the north-west and south-east shores of Morecambe Bay, the Lune and the Leven, may be successfully dealt with. From Chapel Island to the Isle of Foulney the coast of Furness presents strong ground, which has a tendency to throw the channel of the Leven off land, and towards the centre of the bay. Every accumulation of land is by such means counteracted on the coast of Furness. As the course of the tide is from the Isle of Foulney, and bearing on Chapel Island, great facilities are afforded for the construction of a low dike composed of stone, commencing at the former isle, and taking the direction of the latter one, with a view of securing the channel of the Leven on the eastern shore of Furness, and carrying it right into the bay of Fowdry. Were the protective foundations of a channel once fixed only, an effective embankment might then be completed in security, and at no heavy expense, from Chapel Island to Foulney Isle. By such means the whole of Morecambe Bay, along its northern and western lines of shore, would be cut off from the disturbing influence of land streams; whilst pouring their concentrated floods on the Irish Sea, from Pile of Fowdry, they would check the tidal violence of that sea, and scour out a great and invaluable roadstead, fitted to shelter a large commercial navy at all times of the tide. Were tidal force moderated ere it flowed in Morecambe Bay, undisturbed by the counteraction of inland backwater, and flowing up an inclined plain of twenty-five miles in length to Milnthrope, in every tide immense depositions of sand might be expected in the lower portions of the bay, while the finer particles of matter would be borne upwards in the direction of Milnthrope, and form a fertile supersoil. Sward would rapidly overspread the higher portions of the bay, filter the waters of mud, and wonderfully facilitate the process held in view. The space and features of an ascending plain twenty-five miles in length, would retain all the drifted silt driven forwards by a flowing tide, and secure speedy success.

On the side of the river Lune, we should in the first place propose cutting a new channel, from the vicinity of Glasson Docks to the Docker, and from thence to the Cocker below Cockerham, finally directing the course of the channel by wearing or otherwise on the entrance of the Wyre; ever bending to and adopting such plans in detail as appeared to favour the navigation of both these channels—the Lune and the Wyre, as well as the reclamation of land; or Sunderland Point might be extended by wearing, in conjunction with tidal processes on the Wyre; acquiring a sort of tidal battery for the defence of Morecambe Bay on the south, which we have previously projected on its northern shore, directed across and checking the tide-wave on its advance from both extremities of the bay.

It may, by the way, be further observed, that were the central rivers of Morecambe Bay diverted into the Leven on the north, or the Lune on the south, there would be no doubt in sending a travelling beach from the line of Sunderland Point, on Arnside Point, or even Humphrey Head; making the tide-wave in the bay, by a little assistance skilfully applied, effectually embank itself, on the principle of the Chesil Bank, or that of the Low Holm, on the shore of the Solway Frith. Once gain a straightly-projected range of the tideway for a short distance, and it would speedily operate in producing a long one. Hence self-formed marine embankments, directed from parallel to parallel, and from angle to angle, might be thrown up finally in almost any given direction, until a railway were successfully carried from Cockerham to Roose Beck, crossing the rivers Lune and Leven, by ferry apparatus, and thus leaving the navigation channels free. Indeed, viewed in a proper light, the speedy silting up and crossing Morecambe Bay by railway is unquestionable. Any scheme which diverted the river Ken from the centre of the bay into either the Leven or the Lune, must at once set at rest all question about engineering difficulties and uncertainties. At the same time the subsequent plans to be adopted ought to be undertaken on the most mature consideration, as trivial oversights might lead to serious augmentations of expense, ill-adapted railways, and a great deterioration in value of land reclaimed from the sea.

Insomuch, the outlines of a plan for the reclamation of Morecambe Bay from the sea are drawn up, subject to more mature consideration and modifications in detail. Five distinct objects are held in view. First, the eventual construction of a railroad directly across the bay from Cockerham on the south to Dendron in Furness on the north. Secondly, the reclamation of land in Morecambe Bay, and its conversion into a highly fertile soil. Thirdly, acquiring deep water in Pile of Fowdry, accessible for the largest vessels at all times of the tide. Fourthly, the formation of a deep water harbour at Wyreton; and giving to Lancaster a direct communication with that port by steamers in every tide. Fifthly, breaking up those extensive sand banks on the coasts of Lancashire and Cheshire, which impede and endanger navigation. While the plan of operations here drawn up holds each and all of these objects in view, it is in the mean time so framed that the works might be successfully undertaken in sections, without at all depending on the execution of the whole, or losing sight of eventual objects by operations in part only. Not only are these great ends provided for, but sufficient inducements of gain in detail might be securely reaped. Reclaiming the sand of Milnthrope; the formation of an embankment from

Wraysholme to Chapel Island; turning the current of the Leven into Pile of Fowdry; carrying the river Keer into the Lune; and directing the channel of the Lune on that of the Wyre, are each of them distinct considerations within themselves, which are capable of complete combination with each other.

Estimating the sum of £80,000, for works on the north of the bay; the sum of £30,000 on the west; £10,000 on the east; and £30,000 on the south, gives a total sum of £150,000 for the whole scheme.

As concerns navigation, the results expected appear of great national importance. Under all winds and times of the tide, vessels might enter either Pile of Fowdry or Wyreton. Not only might these advantages occur, but vessels bound to and from the westwards, whether by the north or south Irish Channels, would enter deep water at once, and bear along a tidal current, without encountering any local hindrance whatever. The same facilities of making a safe and speedy voyage might apply to Liverpool, were the channel of the Mersey scoured by reclamations of land; and provided the materials of those sand banks, which impede navigation, were absorbed by the measures here suggested.

Reclamations of land in the estuary of the Duddon are so intimately connected with Pile of Fowdry as a place of marine refuge, that the two may be treated upon in connexion with each other, the more especially as some have considered it practicable to wall up the entrance of the Duddon, and turn its stream through Walney Channel into the roadstead of Fowdry. On the practicability of such a plan we shall not attempt to decide. Yet it is obvious that the channel of the Duddon might be thrown from off the Cumberland shore, by a judicious diversion of inland streams and wearing; as the flat ground of Hodbarrow, the prominence of Hodbarrow Point, and Burrow Crails are admirably adapted to further such a plan. Turning the channel of the Duddon, therefore, in the direction of the Walney Channel, and fixing a channel along the coast of Furness, would facilitate all the objects of narrowing the estuary of the Duddon, crossing it by a railroad, rendering it fitter for navigation; and, at a comparatively small outlay of capital, reclaim an extensive tract of land from this arm of the sea. Could the Duddon, therefore, be emptied within the northern extremity of Walney, leaving the channel open northwards as at present, means of entering Pile of Fowdry might be acquired under every wind, as the co-operative force of the Leven on the south, and the Duddon on the north, might cause an easy access on both the north and the south of the Isle of Walney, by a consequent deepening of the Walney Channel. So weighty a body of water as the rivers Ken, Leven, and Duddon, emptying themselves into Fowdry and its channels, could not fail in occasioning a powerful scour within, and on the entrances of this vast and secure roadstead. Nor is this all. The very steps which are favourable to the acquisition of such an object, are equally adapted to the reclamation of Morecambe Bay, and the estuary of the Duddon from the sea. Preparing the way for the construction of a line of railroad that would give a speedy and easy communication between Cumberland on the north, and Lancashire on the south. Opening out at the same time a direct route of railroad, between the south of Scotland, through the west of Cumberland, and the south of England; embracing in a comprehensive plan national objects of vast importance, attainable only by the means here advocated, and through the portions of the kingdom just described.

The reclamation of land, and the improvement of navigation in the Solway Frith, as well as crossing it by a railroad in an available form, are plain and comprehensive. Natural operations already in being, distinctly point out the plans to be adopted. It has been previously shewn that, owing to the configuration of the valley of the Solway, deposits have always had a predisposing tendency to accumulate on the side of Cumberland, and scarcely advance at all on the side of Dumfriesshire. The large bend northwards in the valley of the Eden, in reference to the southwards bearing of the Irish Sea, necessarily produce such an effect.

Hence, though the ground be naturally strong on the northern shore of the Solway, the incident is attributeable to deposition having no tendency to rest there; and if the shore of Cumberland be generally formed of weak ground, that circumstance must be attributed to a reverse law in the current of the Solway Frith. The inference is obvious. Were it not for the disturbing influence of several inland streams, which fall into the estuary of the Solway, on the side of Cumberland, between Maryport and Burgh by Sands, its channel would take the Scottish shore, and assume a narrow, a steady, and even course.

Under these considerations, the first question to be answered is, what are the means of completely neutralizing the influence of inland streams in drawing the channel of the Solway on the Cumberland shore? The answer is at once full and satisfactory. The only streams of much weight and disturbing tendency, are the rivers Wampool and Waver, which fall into the estuary through the spacious opening of Kirkbride Loch. These, it has been proved by levels and sections, may be carried into the channel of the Eden and the Esk at Port Carlisle, or at the sea locks of the Carlisle Canal for a sum not exceeding £10,000; and for an additional sum of £15,000, the entire influence of inland streams, on the English side of the Solway Frith, may be either neutralized or drawn away, from Maryport to Sark-foot and Rockcliffe, on a line of shore which extends 26 miles in length.

The tide-wave of the north channel of the Irish Sea usually turns and divides its stream on Saint Bees Head, as upon a common pivot. So that this bold headland lies in the shed of those waters, northwards and southwards; and an obvious cause is evinced why so much drift-wood or coal has been stranded and deposited on the north of this point, and none beyond it, or southwards thereof. From this strong and iron-bound position, the flowing tide rebounds upon, and has denuded the Scottish coast from Balcarry to Southerness Point, even of the entire tertiary formation. From Southerness to Graitney, a denudation of alluvial beds is plainly observable. Contrasting these evidences with what has occurred on the side of Cumberland,—from Bowness, these alluvial beds, as already noticed, extend 10 miles southwards before any discovery of red sandstone appears. Those several incidents favour a conclusion that, were all inland streams withdrawn or neutralized on the southern shore of the Solway Frith, as previously described, as much as the reclamation of 20,000 acres of land might be anticipated in a few years; causing the channel to assume a regularly curved line from Maryport to Rockcliffe Cross, abutting on Newby and Tordiff Points. Were these plans carried into effect, and the advance of Grun Point no longer checked by the rivers Wampool and Waver, it would speedily extend itself to Cardornock Point, and effectually of itself almost shut out the sea from Kirkbride Loch by a marine embankment constructed of shingle. So that the sum of £10,000 expended in taking the rivers Wampool and Waver from channels, which are alike detrimental to navigation and the formation of land, to a point on which they would promote both of these objects most fully, and therefore prove highly beneficial; thus gaining 4500 acres of highly fertile marsh land without other efforts.

Pushing the line of operations still further eastwards, turning the river Eden into the channel of the Esk, and clearing the northern side of Burgh Marsh from streamlets flowing into the Solway, would add as much as 6000 acres to that marsh; and a limited channel conveying off these united streams, would be altogether thrown on the Scottish shore. An outlay of £10,000 might complete this branch of the works here proposed.

No sooner had these arrangements taken full effect,—and time would speedily accomplish the objects desired, with the channel of Grun Point, as at present existing, then effectually closed, and that of Port Carlisle freely open,—than high spring tides might be expected to inundate the space of Kirkbride Loch occasionally, and experience shows that such inundations are beneficial to those lands, —than a powerful scour around Bowness, facilitated by the operations here described, might be expected to deepen the channel of the Solway, compress its tideway, fix its stream, and carry out Burgh Marsh within half a mile or less of Tordiff Point. Natural laws having accomplished so much, art might then compress the waters of the Solway to a narrow channel resting on this prominent and strong ground. In short, an even and fixed draught of water up the Solway from Maryport, would give more ease and speed to the flowing tide, deepen and compress the channel, and scour out a harbour of first rate capabilities on the new embouchure of the Wampool and Waver into the Solway Frith. No ground can be more admirably adapted to the objects proposed. A firm clay prevails, already shaped into the best forms, and so much advanced on the iron frontier of Scotland, that gaining additional ground is by no means essentially needed.

So far the arrangements proposed in the upper regions of the Solway appear well, and are capable of being carried into effect with great facility. Risk there is none. Indeed, 4500 acres in Kirkbride Loch, and 6000 acres in the vicinities of Burgh and Rockcliffe Marshes, are already so choked up with drifted silt, that no material accumulation is required to convert them into fertile marsh land. In the short space of two years, as shown by ordinary experience, both of those plots of land might be expected to gain a sward, and in two years more yield an annual rental of £1 per acre.

Not only might these advantages be confidently expected, but the plans here proposed being once carried into effect, based on physical operations apparent in the Solway Frith, the works required at the outset would be liable to no future insecurity. Because the channel of the Solway is propelled northwards on an iron frontier of the best description; and because deposits are naturally driven on its southern shore.

Between Maryport and Dubmill, five miles and a half in length, a number of inland streamlets fall into Allonby Bay (two of these have weight sufficient to turn mills), which carry off shingle and sand, and cause the tidal action of the Solway to scour this portion of the coast. All these streamlets might be readily diverted, and carried into the sea on the north side of Maryport. The land here is strong and prominent. At the distance of half a mile from this point, a reef of red sandstone commences, and runs northwards along with the tide on the low water line of Allonby Bay for two miles or so, and nearly two miles within the high tide line. Were the entire streamlets, which fall into Allonby Bay, diverted as proposed, and this reef of sandstone rocks continued southwards until it joined the main land by a low dike of loose stones or wearing, requiring neither much substance nor height, as the waters of the Solway are here sluggish, a fresh travelling beach might be started, parallel with the existing beach, and two miles further from land. So that an additional breadth of land might then be expected to form two miles more seawards, fabricated by those tidal laws that prevail in the Solway, and have hitherto effectually contributed to preserve the line of shore, although repeatedly broken by rivers and streamlets, the diversion of which we have already discussed and planned. A double object is here kept in view. Reclaiming a large area of land from the sea in the first place; and breaking up Robin Rigg and other sand banks in the second place; depositing these banks within the line of the fresh travelling just described. and improving the navigation of the Solway at the same time most materially.

In confirmation of the practicability of these plans, and the strong probability of a successful issue, if carried into effect, as much as from fifteen to twenty thousand acres of alluvial depositions are already formed on those shores. An enormous extent of shallow water in the Solway, the disturbing influence of land streams, and the results of tidal influence already shown, leave no doubt that land might be gained on the Cumberland shore for ages to come, and an excellent navigable channel thereby obtained and for ever preserved.

The construction of a good harbour at Port Carlisle, therefore, deserves our best attention. Were the Wampool and the Waver carried to this port through Glasson Moss, about two miles across, they would be sure to form a deep pool, and with the channel of the Grun closed up, the best incidents would offer themselves for the construction of a good harbour, and the most extensive and capacious docks. Nature has, indeed, established indexes for art to proceed upon, under the most available advantages, locally and geographically, which can well be conceived. For the position here under consideration is but 70 miles distant from Newcastle-upon-Tyne, and would possess a concentrated and undisturbed body of backwater rivalling the river Thames, and meeting in a common pool within a secure and compressed channel, surpassing the advantages of Liverpool. While the premises to work upon are at present all but valueless.

Were a fresh bed cut for the river Eden through Rockliffe Marsh, about a mile in length, on a low level, and readily excavated, into the river Esk, and both these streams embanked on the side of the Solway, drawn to the embouchure of the Sark, as these rivers would naturally be, and forced through the scar of Tordiff Point by art, as they might be, the channel of the Solway would at once take a fixed, a limited, and straight course on either Bowness, or Annan Water Foot. Tordiff Point on the Scotch side of the Solway, and Raven Bank on the English side thereof, are but two miles asunder, and lie in a considerable bend of the channel, which might be brought into a straight line. Both of these headlands are composed of strong and elevated ground close to the shores of the Solway.

Bowness on the English shore, is also about two miles distant from both Raven Bank and Tordiff Point; and almost in the direct line of the channel of the Solway to Tordiff Point and Sark-foot. Consequently, the course of tidal action in the Solway, would have a powerful tendency to silt up and compress the channel, above and between Raven Bank and Tordiff Point, to the extent of 6000 acres, most of which is choked up by sand. The objects here held in view are threefold. The formation of a harbour within the angular space which lies within the lines of Bowness, Tordiff Point, and Raven Bank; reclaiming 6000 acres of land in the upper portion of the Solway Frith; and carrying a railroad from Raven Bank to Tordiff Point. Concurring incidents are favourable to these objects combined.

From Tordiff Point a scar composed of red sandstone descends 400 yards into the Solway Frith; and on which a sure foundation might be obtained at little cost. On this scar, almost uninterrupted by neap-tides, we should propose the building of a stout viaduct, 300 yards in length; and when finished cut a new channel through Tordiff scar for the tide-way to flow along in future. On the channel of the Solway being brought close in shore with Tordiff Point, a speedy silting up of the estuary on its southern shore might be confidently relied upon, such being the natural tendency of this portion of the ground when undisturbed by the river Eden, and whenever it has set in on the Scottish side of the estuary. The channel of the Solway turned through the viaduct of Tordiff scar, and the space from that scar to Raven Bank silted up, or mostly so, an embankment of 10 or 12 feet in height, from Raven Bank to the projected viaduct might complete the formation of a railroad across this portion of the Solway Frith, the advantages of which we shall discuss more at large in the future pages of this work.

As it is proposed to construct a harbour, about half a mile on the western parallel of the railroad here projected, a low and strong dike constructed of stone, would greatly facilitate the works and silting up of the ground to the eastwards; and this dike being placed in comparatively dead water, if its foundations happened to sink 15 or 20 feet, in some parts of the line, it would be the more secure for a harbour afterwards. The angular bight of the estuary, lying centrically between Bowness, Tordiff Point, and Raven Bank, is the spot into which it is proposed to empty the rivers Wampool and Waver, and the river Annan might be driven into this common pool if required. Moreover, in providing for these various works and operations, both Tordiff Point and Raven Bank would afford an ample supply of clay; and freestone of the best quality would be at hand on the Scottish borders.

When the vast importance of amending the navigation of the Solway Frith is held in view; and the commercial position of the harbour projected, favoured with every advantage which railroads and inland navigation can bestow, scarcely more than seventy miles distant from Newcastle-upon-Tyne, and twelve miles from Carlisle; and in direct communication, by railroads, with the west of Cumberberland, Lancashire, Dumfries, Stranraer, Belfast, Glasgow, and Edinburgh, as we shall by and by show, the works here suggested might be realised at an exceedingly light expense. Because nature offers art so many favourable incidents to work upon. Stone of the best quality, and at the cheapest rate would be at hand. Land for nothing; and a railroad across the Solway, presenting a harbour at the same time in one of those favourable geographical positions, of which the British empire affords so many, besides the acquisition of 20 or 30,000 acres of land reclaimed from the sea. Here we shall rest these important topics for the present.

The reclamation of the Wash, on the Lincolnshire and Norfolk coasts, is perhaps the plainest in attainment, and the most important in its objects of any in the kingdom, as concerns the land reclaimable, and the advantages it offers to navigation. Every headland from Berwick to Harwich shows the predominating current of the North Sea to be southwards, and close along and on the English shore. Why such a prevailing current has not silted up the Wash long ago may be attributed to the weight of inland water which falls into a spacious estuary. This fact does not prove the impracticability of such a purpose, but its attainableness. The force of the river Steepina is not equal to a prevention of Gibraltar Point being pushed forwards by wearing; works raised there would have all the advantages of a tidal current working in their favour, and carrying out that point more southwards. Nature points out the plans to be adopted, indeed, in the plainest and most comprehensive forms. By the completion of adequately strong works, operating along with the tidal action, and not against them, most of the Wash might be reclaimed from the sea on self-working principles, and harbours constructed within the area enclosed, accordingly, as future events realised favourable means to work upon.

The various rivers which empty themselves into this large estuary may be unquestionably thrown, by a tidal process, upon strong ground on the Norfolk coast, and from the weak ground of Lincolnshire. The expensiveness of such works can can be no doubtful question. As the tidal current would operate with them, the expense would be trivial compared with the attainable advantages to be gained.

The extended area of shallow water in the North Sea, would speedily supply enough of material to silt up the Wash. A place of repose for drift to rest upon is all that may be required. By plainly following the Geological sequence, on which the entire of the south-east section of England has been formed, the Wash might soon be reclaimed from the sea; and excellent harbours would be sure to follow, when a body of inland backwater so powerful as the waters of the Ouse, the Nene, the Welland, and other streams were concentrated on strong ground like the Norfolk coast. Then the ports of this great section of the kingdom, might rival the most favoured ones on our shores; affording places of refuge at all times of the tide were skilful plans adopted.

Probably enough, it might be advisable to commence a line of works some miles to the northwards of Gibraltar Point, as well as upon that headland, and directing the whole southwards on a common base line, with a view of gaining the general trending of the Lincolnshire coast. Causing a travelling beach to start in the direction of the tideway on a straight course. Certainly, in operations of this sort, available incidents discover themselves, which skilful engineering might turn to account. In venturing on a general outline, therefore, details ought to be modified as occasion presented themselves, and plans varied accordingly. Principles are here given only, rather than details which require to be modified and accommodated to practical and accidental events. That the broad area of the Wash may be effectually and speedily silted up by an adoption of the principles here propounded, is unquestionable; and the rest of the subject may be fairly dismissed in the mean time.

The complicated currents under which the estuary of the Thames is placed, forbid our entering into details on this important and entangled ground, or even deciding on the general rules by which it shall be treated, except in correspondence with tidal laws previously described. That highly advantageous diversions of inland streams might be made, and beneficial jetties be projected cannot be doubted. But a near and cautious observance of its leading features is obviously required before correct plans could be framed. The current of the river Thames does not flow along with the tidal current of the North Sea, as is the case in Morecambe Bay and the Solway Frith; but like the Wash, the inland and sea currents cross each other. With this difference, Landguard Fort, opposite to Harwich, lies much further inland (and so breaks any right forward line of depositions) than Gibraltar Point on the north-eastern extremity of the Wash. Orfordness, on the Suffolk coast, it is true, lies in a line with the North Foreland on the side of Kent. Yet an attempt to push land forwards from those places is inadmissible. Again, sheltered by Landguard Point, the prevailing balance of currents at the Naze is northwards, and therefore by no means adapted for the projection of a travelling beach southwards. From Shoebury Ness on the south, to the Naze on the north, the ground is indeed exceedingly complicated and broken in outline. Intricate to deal with, therefore, and requiring repeated attention and reconsideration. The same may be said of the southern shore of the Thames from the Isle of Grain to Foreness Point.

Such reasons by no means show that a large area of valuable land is not irreclaimable from the sea in this estuary; and that the navigation thereof is incapable of material amendment. The very fact that the ground is broken and complicated is a full assurance to the contrary; and leads to a conclusion that a few immaterial cuttings and embankments might effect national objects of great importance. Not only might the land reclaimed prove highly fruitful, owing to the fertilized alluvian emitted by the Thames, but great facilities to navigation would be sure to follow. The very features and character of the estuary of the Thames would seem to promise available advantages of considerable moment, were skilful plans carried into full effect. The want of strong ground to work against and towards may be a defect. The flatness of the adjoining land may certainly be a compensation on the other side, as cuts are more readily available, sluggish channels may be securely walled up, and effects produced by such measures would yield highly beneficial results.

In casting the eye on the vast attainable acquisitions which appear on the coasts of Lancashire and Cheshire, in the estuary of the Solway Frith, that of the Wash, and the Thames, they may be viewed as objects of great national importance. The mere reclamation of land from the sea is not the sole consideration, but the facility and security of navigation on one-third of our English shores, besides giving the cheapest and best direction to railroads, and thereby effecting the most speedy communications between the different parts of the empire. We may be well allowed to express some surprise that national attainments so important should have been so far neglected, the more especially as they offer to the speculator ample and sure returns of profit, and might well rouse the attention of Government and the Legislature. Now that railroads have become essential to the preservation of our high station among the various nations of the earth; as Morecambe Bay and the Solway Frith, sever almost the inland communications of England, Scotland, and Ireland, they surely claim intense national interest. Not overlooking at the same time the grievous consequences of a false direction given to capital in the construction of railways on lines where the cost is enormously high, undulations and curves exceedingly objectionable, the working powers expensive, and the communications from some parts of the empire to others tardy and dangerous; even passing through sections of the kingdom all but barren, avoiding the fruitful plains, manufacturing workshops, and commercial storehouses of North Lancashire, and western Cumberland. Nor is this all. Turning the communications of the west of England and the manufacturing districts of the north of England, with the south and west of Scotland, by Newcastle-on-Tyne alone, could not fail in eventually producing serious national evils. Yet this would seem to be the result. It would therefore appear to be the duty of Government to enter forthwith upon an enquiry which involves so many national interests of the highest moment. By no means overlooking at the same time the evils which attend a false direction of our national capital, which even passing events are rapidly bringing about. We shall now leave these considerations in the mean time, and proceed to a more legitimate object of our work, the bettering of bar harbours.

To notice a few of these may, however, suffice. Nor is there any one which claims more attention, nor affords more decided proofs of the nature of such harbours, than Tynemouth bar, on the entrance of the river Tyne. The cause of this bar has been already noticed—namely, the flowing tide of the North Sea, sweeping strongly across the mouth of the river Tyne, at almost a right angle, deposits a bar of sand on the best navigable course of the river. A place of comparative repose on which silt has a tendency to rest is, therefore, the cause of the bar, since it is formed precisely in the water which is sheltered by the headland of Tynemouth Castle, and fails in a returning eddy, or rebound on an inactive space of water. Within the bar, or immediately between that and Shields, an eddy obtains which scours the river and deepens its channel. Even within the course of the Tyne, and beyond the limits of the eddy just noticed, the channel of the Tyne has an abundance of water, owing to the draught of the tide up and down the river, the weight of occasional land floods. and the effect of Jarrow slack, which necessarily augments the tidal velocity, force, and volume of water at Shields. The removal of Tynemouth bar clearly depends, therefore, on giving additional motion to a cross current flowing adversely to the north and south current of the tideway. The water on the bar certainly exhibits action enough, and yet it flows inadequately. This is the precise desideratum required to be overcome. Were piers carried out into deeper water, the same objection would remain on the extreme point thereof; the cross tidal current of the North Sea would, nevertheless, prevail. Such piers might change the position of the obstruction only, and cause a fresh bar to form more seawards. Cutting a channel through the Park, out of Priors

Haven, directly in the line of the Tyne at Shields, and so insulating the ordnance ground, might probably give the effect sought for, inasmuch as an eddy flowing around this insulated space might not act sufficiently upon the bar, or it might be left still more within the channel of the Tyne. Both of these causes of failure would certainly appear improbable. Yet a previous and more direct plan might claim adoption. Namely, constructing a stone dike on an inner angle of from 30 to 45 degrees, completely across the southern extremity of the bar, so that the tidal current, in place of flowing directly southwards on the line of the bar, impeded in its course by a breakwater placed directly across its line, would be driven across the bar. A current might be expected to encircle the breakwater, as around an island, and so obviate an area of comparatively dead water which occasions the formation of a bar. That is, we should propose to place a breakwater, with open ends, some 7 or 800 yards south of Tynemouth Castle, and say ranging from north-east to south-west, commencing more seawards than the line of the bar. As an eddy already exists within the range of these several lines, and more immediately in the vicinity of South Shields, this eddy might also be expected to return across the bar, and aid in producing an adequate current of water on all points of the channel.

A third plan of correcting this bar might probably be adopted with more certain advantages than either of the two already named. By erecting a strong jetty upon the present line of the bar, resting such works on the Black Middens, and directing the jetty southwards, until the tide-wave and the river Tyne met on a low angle, which reciprocally scoured off silt on both sides of the angle, instead of a right angle which deposits it, as at present. Nor is this all, such a plan would shelter the embouchure of the river Tyne; and proportionally as such works were directed southwards, they would give out evidences at every step as concerned the measures and plans of the future. On ordinary principles of physics it is obvious that a river crossing a tide-wave suddenly, or at right angles, must occasion a bar; while two angles running on slow progressions into each other, must contribute materially to obviate the objection, and give the desideratum sought for, a flowing stream from an inland drain, working conjointly with a flowing tide, so that a deposition of silt no longer occurred on the extreme angle of their junction. For two currents crossing each other at right angles, of which the deposition of the south-east section of our island is a striking illustration, have a tendency to drive each other away, and necessarily place a line of sedimentary depositions between them. Hence the Strait of Dover is kept open by an eastern and western tide-wave abutting on the coast of France.

Perhaps a fourth plan still more effective, practicable, and yet cheaper than any of those previously named, might be to cut a deep navigable channel, close to the escarpment of the Spanish Battery rock, in a line with the Rock-ends, and the eastern or low water terminus of the basaltic dike on Tynemouth Abbey rock; so that a relaxation in the tide-wave, pressed out by the projection of a basaltic dike, might fall in again upon the line of the bar and sweep it away. It is obvious that the projecting rock on the south of Prior's Haven, turns off a reflected tide-wave, and aids in producing a bar. Hence lengthening the basaltic dike, and shortening the corresponding rock on the south of Prior's Haven, would bring a reflecting tide-wave upon the bar, or facilitate the power of a few other works that might be raised: and thus, by a submission of these several plans, we trust that it is shown how carefully any plan ought to be considered before it were adopted and carried into practical operation. Nor is it at the same time less apparent, what trivial changes might render Shields one of the safest ports of refuge on our shores, and capable of entrance at all times of the tide.

In the planning of such works, angles and spaces mathematically adjusted, would obviously remove the bar, by preserving an adequate flow of water on every part of the channel. Whereas, false estimates of angles and proportions would be sure to fail. Incidents are therefore worthy of the strictest notice, before works were undertaken; and while a plan were framed on general principles, yet peculiar positions would claim the fullest attention and reflection. Dublin bar is an instance somewhat consimilar to that of Tynemouth, though the headland of Howth is on the reverse side of a flowing tide. As spaces, positions, and incidents, necessarily vary, a line of operations therefore corresponding to the case in hand is ever demanded. Moreover, no sooner were works entered upon and effects produced, than fresh suggestions would naturally follow, and point out such a prolongation or shortening of walls as put all the waters of a continuous channel in direct motion, securing a constant and easy line of navigation. The want of experience in works so designed, is, we confess, a great desideratum. Nevertheless, as the cause of such bars is plain, and the object in view equally so, with incidents to work upon before us, the means to be employed could scarcely be mistaken. A deliberate and critical survey of given premises, aided by future experience, are sure to attain the knowledge required in the removal of fluviatile bars by tidal action, and thereby better the entrance of tide harbours, or giving sufficient water at all times of the tide for the entrance of the largest class of vessels.

Harwich is an instance of a cross current prevailing in conjunction with a good navigable channel. Other applicable cases might be collected; and if we view the tidal laws which scour the north Irish Channel, and bar the Strait of Dover, no remaining doubt can be entertained, that apt combinations of open-ended breakwaters and projecting jetties may be so planned, as to render the removal of bars almost certain in any case. Suppose that either Tynemouth or Dublin bar did not yield to an opposing breakwater, a counter pressure by jetties resting on shore, might often contribute to the production of the effect desired. We shall forbear to offer further plans in this place, as experience and observation applied to each particular case, ought to determine the works constructed. The principles of operation is all that we can here fairly venture upon.

Whitehaven harbour neither depending upon backwater, the scour of an island, nor the westwards current of the ocean, affords an instance of tidal operations, which seldom occurs. The tide-wave of the north Irish Channel, sheds its waters on Saint Bees Head; then flows southwards into Morecambe Bay, and northwards into the Solway Frith. Hence the peculiar prominence of tertiary depositions and close of carboniferous limestone and coal measures at that point of land. During the continuance of the south-west gales, which are the prevailing ones, the water-shed is necessarily carried more northwards; and a temporary scour is directed from Saint Bees Head into the Bay of Whitehaven. While these gales last, therefore, a torrent of water is driven from off a promontory as it were into a large chasm, it clears away silt to the bare rocks, and a boisterous surf is raised, which greatly endangers navigation. The cause of a harbour existing here at all, gives rise to a material defect at the same time, which has partly baffled engineering skill, and too often proved the grave of the mariner. If the harbour be not somewhat prominently advanced towards the sea, it wants water. If it be open northwards, silt accumulates under the shelter of its western bulwarks; and it lies exposed to the destructive effects of north-west storms. In remedying these striking defects by the construction of northern defences, a heavy surf in south-west gales ranges across the entrance of the harbour, and renders its access precarious. Worse far, in every failing attempt to enter Whitehaven under such winds, the unfortunate vessel is speedily swept northwards, to all but certain destruction.

What then is the proper remedy? By no means an attempt to reconcile general defects by petty details; but by the adoption of appropriate principles in the plan of the harbour. Two leading modes offer themselves at a glance. Either a double harbour, or a sheltered roadstead. The construction of the present harbour conforms to neither of those principles. It is simply an enclosed area, sheltered by a western and a northern wall. Between the north wall and Redness Point, a space of water lies similar in principle to what the harbour would be, if the north wall had no existence. By giving this wall a western as well as a northern range, while the present provisions of the harbour were all preserved constituted as they are, a place of refuge might be afforded to vessels that failed in making the harbour in south-west winds, on the very ground where their destruction is all but inevitable. In point of principle, Whitehaven would therefore possess a double harbour, inasmuch as the dangers of south-west winds were provided for and obviated.

It is not improbable but that a double entrance to the harbour as now formed, might give a tidal scour which rendered it easy of access at all times of the tide, without diminishing its security. In making an additional entrance, to produce the effect desired, a careful consideration of spaces, in combination with prevailing currents, and the erection of a few requisite defences, might speedily render Whitehaven one of the best harbours on our shores. Lying immediately adjacent to deep water, with the Irish Sea open, both the outlets of the Irish Channels before it, and a pair of tide-waves hanging on St. Bees Head, vessels might be brought into this noble harbour, as if so many tubs floating along tidal currents to embayed moorings. The same tidal laws that secured the drifted forests of the north of Europe on this point of land, is not less adapted to shelter ships for the reconveyance of that drift-wood to distant markets. But in saying thus much, it is obvious that such a harbour can never be obtained by either factious representations or indiscretion. So much is already accomplished, and we shall not say that it might have been so far materially better. For it may lead to what was the best at the beginning, and might not then have been foreseen. Treating on the construction of harbours, in truth and open fairness, we may be allowed to give examples, and make our deductions accordingly.

Had a protected roadstead been adopted as a common place of refuge in the northern section of the Irish Sea, and that is seemingly the plan which ought to have been taken, the relative bearings and incidents of Whitehaven are so consimilar to Cherbourg in France, that the latter afforded a perfect model, by which the former might have been constructed; and the author of these pages ventured on stating so much before Sir John Rennie adopted the final plans which were acted upon. In mitigation of these opinions, however, we readily confess that Whitehaven harbour is entangled by complications that render its planning difficult and somewhat precarious. In so far a degree of failure in the plans adopted, by no means impugn the professional credit of that justly celebrated Engineer; and we shall indeed presently show how much art and science has been here displayed. In respect to a roadstead at Whitehaven we need scarcely add more. An ample space of ground, a breakwater sufficiently seaward, two spacious entrances, and justly balanced bulwarks raised on Tom Herd's Rock and Redness Point might have sufficed; and this we think was practicable at an available expense. Wet docks might have then been built within an area so enclosed to any extent required. When reduced to proper dimensions the terms under which the Bay of Whitehaven stands, are simple. A balanced water-shed rests upon Saint Bees Head, and prevailing winds temporarily disturb that balance. These are the real incidents to deal with and provide for. A truly proportioned breakwater applies to check and bridle the tide-wave under all circumstances. Then a tub might have gaily floated to secure moorings.

Whatever the merits or demerits of Sir John Rennie may be as concern the general plan of Whitehaven harbour, the profound art and science he has displayed in planning its west wall, it would be unfair to pass over unnoticed. Had such wall been drawn in a plain line, as any inexperienced and unscientific man would have done, during south-west gales an unbridled torrent must have swept along its course, and rendered the harbour inaccessible. In even some measure, perhaps, though the north wall had never been erected. To break the force of south-western torrents during the continuance of south-western gales, Sir John

Rennie has therefore formed the face of the west wall seawards, into two concave curves. These undulate a passing torrent, break its force, throw it off, and mitigate its injury exceedingly. Moreover this pair of concave curves, is but a continuation of angular ground from Tom Herd's Rock, on which the commencement of the wall nearly rests. By adopting a form so simple and yet efficacious, south-west torrents are broken and the wall strengthened in the meantime. Hence at a future day, when ignorance has been hushed, and bile gone to rest, Sir John Rennie is sure to retain an engineering reputation of the highest order. Nor ought a lesson so valuable in the construction of harbours to remain unobserved by the engineering world.

Perhaps, however, the powerful backwater stream of the river Derwent, affords more certain means of constructing a harbour of refuge at Workington, than on any other point within the limits of the Solway Frith. Were a bold projecting breakwater rightly placed to the southwards of the embouchure of the Derwent, operating similarly to Saint Bees Head on Whitehaven Bay, the flowing tide-wave dropping on a line of incidence upon the entrance of Workington harbour, would be sure to render that admirably sheltered port either accessible to vessels of considerable burthen, or nearly so, at all times of the tide. The more especially, when the results produced suggested additional works at the immediate entrance of the harbour. As regards a well known travelling beach on the north of the harbour, it would fly before the battery here proposed like chaff before the winds of heaven. The rebounding tide-wave would be sure to fall thereon, and sweep it off; finally producing a bight and scour from both the flowing and ebbing tide.

Maryport harbour might have been similarly constructed, had not art spoiled what tidal laws had presented on the embouchure of the river Ellen; or to apply the emphatic words of a near observer, "God Almighty (in a high tide) had done more good in an hour, by pulling down what had been put up in twenty years, than all their harbour projectors put together." But experience has been disregarded; and those very works have been carried out still more effectively a few years back. Consequently, a breakwater, for which high merit is claimed, is built much too near the harbour and embouchure of the river Ellen, which, similar to the incidents in the brook behind Grun Point, has a strong tendency to silt it up and bar the river channel; while in south-west gales vessels are apt to be driven past the harbour, and stranded on an angle of incidence about 650 yards to the northwards thereof. The scour of the flowing tide passes the harbour altogether, and falls upon a tanyard with all its fury. There the embouchure of the river Ellen and the harbour ought to have been. But death and destruction lie upon the spot. Previous to any works being erected in defence of the harbour, a plot of green ground intervened between this tan-yard and the beach, showing that the breakwater ought to have been placed on the line of incidence southwards, so as to have brought a scour on the embouchure of the river, and thereby carried vessels into the harbour.

As a subject of science we certainly dismiss the construction of harbours hastily. The tidal laws described in these pages, we trust, however, may lead to a more extensive range of enquiry, verified by experience and illustrated by examples. We certainly feel that we have probed the fountain where true knowledge on this head lies. Providence may be pronounced a universal Engineer, that has left no principle in the construction of harbours un-illustrated, nor any modifications in detail without complete examples to go by. It is true that these require a nice discrimination in practice, accurate observation, great ability, and much experience or communion with physical laws. An ardent hope is at the same time held forth, that a species of knowledge which has become so essential to the marine safety of British life and property, and the unslackened success of our industrial energies, may speedily gain that national attention which the subject so imperatively demands. In truth, to handle these matters as they deserve, we must seek for a body of facts yet ungathered; means of obtaining them must be resorted to, mature consideration and reconsideration must be honestly bestowed upon them, and in this laborious way we must continue to unroll the hidden papyrus of tidal laws.

In the construction of harbours, an amendment in the channels of navigation on our coasts, and in the reclaiming of land from the sea, an eastwards motion of the earth, a westwards tendency of oceanic currents, and a usual accumulation of drift on the terminus of any tide-wave, would seem to claim intense examination for our guidance in future. Next in consideration to these first premises may be viewed the local configuration of any shore in reference to oceanic currents and inland backwater. By such means gaining an acquaintance with incidents which concern some of our best interests as an industrious and happy people.

CHAPTER VI.

ON THE APPLICATION OF GEOLOGY TO THE LAYING OUT OF RAILWAYS IN ENGLAND, SCOTLAND, AND IRELAND.

IN the application of Geology to the laying out of Railways in the United Kingdoms of Great Britain and Ireland, as population may in some measure be considered a basis of traffic, and a criterion of the extent of inter-communication, we shall assume that an adequate return of profits, and the propriety of adopting the highest facilities of commercial intercourse, mainly depend upon the several masses of population which are found within the range of given termini. We shall accordingly proceed in the classification of England, Wales, and Scotland, into commercial sections, communicating with each other and Ireland also, with a view of framing just outlines of an extended scheme of railway ramifications, suited to the configuration and surface of the United Kingdoms. According to the census of 1831, Scotland had a population of 2,365,000 persons. On this basis, we shall assume that the existing traffic which obtains in our island between any two masses of population to this extent, admitting the ground to be tolerably favourable, may return an adequate rate of profits for a Railway communication from the centre of the one to that of the other, or from and to the largest towns in both sections. For instance, from Glasgow to Liverpool and Manchester by the most favourable and attainable route, as the counties of Cumberland, Westmoreland, Lancashire, Cheshire, and Staffordshire, contain a population of 2,558,000. It is therefore assumed that Scotland can afford the cost of constructing a railway into this section of England. This granted, and, which seems undeniable, our first premises allowed, we shall proceed accordingly.

We also find that the ports of Newcastle-upon-Tyne, Hull, London, Bristol, and Liverpool are each of them commercial entrepôts to sections of population equal to the kingdom of Scotland; and therefore conclude that each of those sections can afford the charges of a railway communication with each other. The population of each of these divisions stands as follow. Middlesex, Oxfordshire, Berkshire, Surrey, Kent, and Sussex, 2,893,000; Herefordshire, Worcestershire, Gloucestershire, Wiltshire, Somersetshire, Monmouthshire, Hampshire, Dorsetshire, Devonshire, and Cornwall, 2,729,000; Lincolnshire, Rutlandshire, Leicestershire, Northamptonshire, Norfolk, Suffolk, Cambridgeshire, Huntingdonshire, Bedfordshire, Hertfordshire, Buckinghamshire, and Essex, 2,500,000; Northumberland, Durham, Yorkshire, Derbyshire, and Nottinghamshire, 2,283,000. Wales has a population of 805,000. To sum up the whole in sections, we find in

Scotland, a population of . .	2,365,000
Liverpool, or the north-west section	2,558,000
Bristol, or the south-west . .	2,729,000
Newcastle, or the north-east .	2,283,000
Hull, or the East Midland .	2,500,000
London, or the south-east . .	2,893,000
Wales, or the west . . .	805,000

Each of these sectional areas of England may be assumed as equal in territorial wealth and commerce to the kingdom of Scotland; and corresponding to those sections we find five leading ports, London, Liverpool, Bristol, Newcastle-upon-Tyne, and Hull. On such a view of the question in hand, it is obvious that each and all of these great commercial and marine stations ought to be in direct communication by railways. Or applying our proposition in round numbers, where the sectional sum of population exceeds 2,000,000 of persons, a direct means of intercourse by railway ought to be supplied, or what amounted to the same thing indirectly. London, Liverpool, Bristol, Newcastle-upon-Tyne, and Hull, are therefore the respective termini from and to which railways ought to run. The rule laid down is now plain. Assuming that Wales could not fail in being justly considered and provided for under such general arrangements, we shall next endeavour to apply our rule.

As the north-west and north-east sections of England equally borders on Scotland, so ought they to enjoy distinct lines of railway to Edinburgh and Glasgow. Next, a common circuit of railways ought to run continuously from Newcastle-upon-Tyne to Hull, London, Bristol, Liverpool, and through the west of Cumberland by Carlisle to Newcastle-on-Tyne again. But this might not be enough. The route which connected Hull with Bristol in a a proper manner, is not by London—a direct line of railway is required. The same may be said of Liverpool and London, and of Liverpool and Hull. For the rule is, that each section of the kingdom in which population exceeds 2,000,000, demands a direct communication with any adjoining section. This being the general basis of a scheme of railways for Great Britain, the position of our various inland towns, and the face of the country locally being also taken into account.

Ireland here claims our attention. As a great commercial and marine station on her north-east shore, Belfast ought to be in communication with Glasgow and Newcastle-upon-Tyne by way of Carlisle. Stranraer is a natural pivot on which these respective lines converge. The more especially as it affords full means of constructing and perfecting a port of the best class in the centrical position of the north Irish Channel. By the adoption of a steam tug, vessels might gain and leave this vast haven under all winds, and at all times of the tide, for any part of the world, as the Irish Sea opens alike into the British Channel and the Atlantic, the north Channel is directly open southwards, and the Atlantic northwards leads by the North Sea to the north of Europe. Moreover, vessels are at once in deep water on leaving a harbour so truly excellent, and sheltered under all winds. Advantages so pre-eminent ought not to be overlooked.

Nor should our great industrial workshops, in a general scheme of railway communications, as Manchester and Leeds, Birmingham and Sheffield, and other inland towns be passed over. Whilst the minor ports, such as Maryport, Workington, Whitehaven, Lancaster, Wyreton, Blyth, Shields, Sunderland, Hartlepool, Stockton, Scarborough, Whitby, Goole, Boston, Yarmouth, Harwich, and the ports of the British and Bristol Channels deserve consideration and notice. These, however, as well as the minor Scottish ports and towns, may chiefly conform to a national scheme of railroads, which brought the chief ports at the same time into communication with each other. Manchester, Leeds, and Sheffield lie between Liverpool and Hull; and York is between Liverpool and Newcastle-upon-Tyne. Birmingham too is on a line which our leading scheme embraces. The ports of western Cumberland lie on the direct route from Liverpool to Stranraer and Glasgow; and the trunk lines here proposed would either go directly by the chief cities and towns of the kingdom, or admit of easy branch lines being locally formed. The wants of England and Scotland are so far embraced in comprehensive and general plans, which admit of being carried out in equally practical details. Combining and providing for the local interests of our vast and varied industrial means in the most harmonious manner. Nor would the completion of a scheme so varied and extended overlook local interests, and the leading wants of the nation.

Our sister isle, Ireland, containing a population of 8,000,000 of persons, here claims special notice. Her communications with England are chiefly provided for by steam navigation. Nevertheless, as the north-east pivot of England, Newcastle-upon-Tyne, would seem to demand a direct and speedy means of intercourse with Belfast, and with the main centre of Scottish commerce also, Glasgow—the elegibility of our national railways centering on Stranraer and Port Patrick, from Carlisle and Dumfries on the one hand, and Greenock and Ayr on the other, appear exceedingly obvious. So much admitted, the correctness of combining Belfast, Newry, Dundalk, Drogheda, Dublin, Waterford, Cork, and Limerick, the chief sectional ports of Ireland, by a common line of railway, is apparent. The outlines of a general scheme of railways for the United Kingdoms of Great Britain and Ireland, must be viewed abstractedly, and as a formula in scientific investigation, to be reconciled and modified in practice to the various contingencies which attainable plans determine.

Geology points out the leading features of the ground on which it is proposed to construct these several lines of railway. As the different formations of which our island is composed, have been chiefly deposited by currents which have flowed from north-east to south-west, it is obviously a general rule, that following the courses of these currents, must contribute to cheapen the formation of railways, and facilitate locomotion, much more than going transversely over them, or from north-west to south-east; and it must prove still more difficult and disadvantageous to cross the Penine chain of hills in the north of the kingdom, where either the secondary or the tertiary formations abound, until the red sandstone group appears. What has gone before throws great light, therefore, upon this portion of our investigation. The most elevated and rugged ground prevails in the central parts of the kingdom; and it is far less undulating to go along with the lines of continuous currents, than taking lines of railway across them. We find beside a series of plains which stretch from the basin of London and Bristol, to the Solway Frith, and lying on the western borders of the kingdom. A similar plain is extended along the eastern borders of the kingdom from the London basin to Newcastle-upon-Tyne. In as much as the most accessible lines of railway may constitute a question, we have at once satisfactory and conclusive information—strictly conformable with geological causes. It is comparatively easy to obtain an advantageous line from Newcastle-upon-Tyne to London; from London to Cheltenham by the valley of the Thames, with a lateral branch to Bristol, and the south-west counties of England generally. From Cheltenham a plain also runs directly northwards as far as Dumfries and Carlisle, by the vallies of the Severn and the Weaver, along the vast levels of the red sandstone group, and by the diluvial and alluvial depositions on the west of Lancashire, across Morecambe Bay, the estuary of the Duddon, and by the western shore of Cumberland across the Solway Frith to Dumfries, and laterally to Carlisle. The entire track of this great line of continuous levels is scarcely undulating, on a low general level, and remarkably straight, considering its length and the varied directions of its lines.

A railway on a dead level and in a straight line, it is an admitted rule, may be safely traversed at the rate of forty miles an hour, without waste of propelling powers, or excessive wear and tear of machinery and rails. In travelling at a less speed, therefore, what is gained in power is lost in time. So economy in the working of railways in a great measure depends upon a capability of travelling at the standard speed, or at the rate of forty miles an hour. With railroads equal to this standard rate, but retarded by undulations and curves, until twenty miles an hour is as much as may be safely accomplished, and with even more injury to machinery and rails at this highly reduced pace. On such terms, the practical distance is doubled in propelling powers and in time, on the rate of locomotion. Thus, if the measured length of the London and Birmingham railway be 112 miles, and to Wolverhampton be 13 miles more, making together 125 miles, be traversed at the rate of twenty miles an hour, the practical distance is therefore 250 miles, as regards the working powers, and time required in travelling. Suppose the best obtainable line of railway from London to Wolverhampton, by Cheltenham and Worcester, were 150 miles in length, and free enough from curves and undulations to be traversed at the rate of thirty miles an hour, the practical distance of this line of railway would be 200 miles. Hence the vast importance is apparent of carrying railways along level and straight lines as much as may be, not to say how much less expensive they commonly are in construction.

Making a fair allowance for retardation by gradients and curves, the great circuit line from Newcastle-upon-Tyne to London, and from London by Cheltenham and Whitehaven to Dumfries, may be probably traversed at the rate of thirty miles an hour. In crossing the central ground of the kingdom transversely to the lines of geological depositions, from fifteen to twenty miles an hour may be considered as an ordinary rate of speed. The London and Birmingham line by Rugby, and from Birmingham to Liverpool in continuation, taken at 210 miles, may require, on an estimate by Mr. Stephenson, as much as ten hours to traverse the whole line, or less than at the rate of twenty miles an hour.

If a line of railway from London to Liverpool, by Cheltenham, Worcester, and Wolverhampton, by the vallies of the Severn and the red sandstone district, were 235 miles in length, and where undulations and curves are few and trivial, at the rate of 30 miles an hour, the whole distance might be traversed in seven hours and fifty minutes, or in two hours and ten minutes less time than by the Birmingham line; and, of course, an equal saving would occur in the working powers of the railway. Nothing can show the true principles of laying out national railways more distinctly. Dead levels and straight lines, or the nearest possible to these requisites, have every merit to recommend them in preference to undulations and curves, which miss important towns, are more difficult to branch from, demand more capital in construction, are more dangerous to travel upon, are annoyed by tunnels, are more expensive in working powers, are more destructive to the rails, occasion a serious waste of time, and great commercial delay and inconvenience.

From London by Cheltenham, and the west of

Cumberland, to Tordiff Point in Scotland, may be taken by railway at 350 miles. As such a line would be remarkable for low levels, few undulations, little pestered with curves, and few tunnels, the whole distance might be gone over in 11 hours and 40 minutes, or 1 hour and 40 minutesmore time than Mr. Stephenson assigns for traversing the line from London to Liverpool by Birmingham. These various facts, which experience verifies, and the most celebrated engineers of the day confirm, show the superiority of carrying our national railways, trunk lines especially, along the western plains of the kingdom, in preference to those unceasing undulations and objectionable curves, which geological incidents have decided; besides the importance of setting free the intercommunication of the kingdom so much more effectually. For London, Birmingham, and Liverpool are not the whole empire. Nor can it be doubted but that striking defects in our railway system, if system it can at all be called, may be remedied before long. A grand connection railway cannot fail in opening out a direct communication between the west of England and Liverpool, by Cheltenham, Worcester, and Wolverhampton; going also by Worcester, Bridgenorth, and Shrewsbury, to Port Dynllaen, in North Wales. The legitimate interests and wants of Worcester, Bridgenorth, and Shrewsbury, cannot fail in gaining the attention of capitalists, and obtaining even-handed justice at the hands of the legislature; the more especially as a line by Worcester and Wolverhampton affords the speediest and most economical means of reaching North Lancashire, the west of Cumberland, and the south-west of Scotland, from the metropolis of the empire, as well as Liverpool and Manchester.

The vital error of carrying railroads across Geological ribs of iron, in preference to traversing smooth and plastic plains, where nature cheers art onwards in every form, is manifest, cannot be denied, and is sure to be remedied in due season. In a day when millions of money are either in course of expenditure on railways through almost every part of the kingdom, or projected, general levels ought to be taken forthwith, and themost advantageous lines ascertained.

The comparative difference between lines of railroad suited for travelling at the rate of from 15 to 40 miles an hour, is a consideration so important, that twice the distance on dead levels and straight lines, may do more than counterbalance what is lost in propelling powers and retardation by undulations and curves. In expense of construction, and working powers also, rugged and curved shorter lines may comparatively exceed longer ones, carried along alluvial and diluvial plains. As the route by Cheltenham, Worcester, and Wolverhampton, from London to Liverpool, does not exceed by more than 25 miles the shortest practicable one, not only might that loss be more than made up by superior ease of construction, and time of traversing, but could be worked by less expensive propelling powers. Continual undulations and curves are not in truth so adapted to locomotive power, as comparatively dead levels and straight lines. Having thus shown the direction in which these may be obtained, south of the Mersey, and on the western side of the kingdom, we shall now proceed to an examination of the ground in continuation on the north-west.

Not to pass over the Midland counties in this place, however, we may shortly observe that a direct line of railway, from London to Leicester, is but a choice of objections. Because Geological depositions trend from north-east to south-west. A line going from south-east to north-west, must, therefore, cross those depositions, and encounter vast obstructions from undulations, curves, and tunnels. A question may be here started whether a line by Oxford might not have been the most eligible one; turning the Geological ribs of England inpreference to crossing them. Certainly the line of the London and Birmingham railway, in going directly to Rugby, attains a central position in the kingdom, from whence Leicester and Derby may be reached, and in continuation by the valley of the Trent, Nottingham, and Gainsborough. The expensive line of the London and Birmingham railway may be so far justified. Not on account of its excellence as a Birmingham line, therefore, but as a midland communication, which took the direction of a common base line, from whence the various Geological basins it bisects may be subsequently traversed and finally turned. Taking the line of the Nene or the Welland, for instance, to Stamford, and then following the course of the great eastern level of England to York and Newcastle-upon-Tyne; yet the Cambridge line is so far preferable. But a line from Gloucester to Boston may be probably called for at some future day.

No sooner are we across the river Mersey northwards, than we find an unbroken plain extended from Warrington to Preston and Lancaster. Here the question arises of crossing Morecambe Bay on the one hand, or scaling the vast and continuous primary Isle of Cumberland and Westmoreland on the other. From Black Comb and Bootle in the west of Cumberland, to Marsham in Yorkshire, the line of these mountains is unbroken. Even the lowest passes attain mountain heights; and excessive tunnelling through the secondary formation is unavoidable. In passes so limited and numerous, repeated curves, combined with ascending and descending plains, would inevitably diminish speed, and augment the expense of propelling powers excessively. On such terms, travelling at the rate of 15 miles an hour, might be considered a high speed, and barely within the verge of considerable danger.

On the contrary, in crossing Morecambe Bay, these objections are completely obviated. A plain through western Cumberland is found without undulations and curves of any moment, which is continuous to Dumfries. Crossing the Solway Frith from Raven Bank to Tordiff Point, as previously described, and passing through the towns of Whitehaven, Workington, Maryport, and Annan. An equally favourable line may be obtained to Carlisle, and junction with the Newcastle and Carlisle railway. Contrasting this line with its mountain competitor is ridiculous, provided Morecambe Bay, the estuary of the Duddon, and the Solway Frith may each and all be successfully crossed by a railway. This is the true problem to be solved, and from which we shall not flinch, but fully and fairly meet the several incidents belonging thereto.

It has been shown that Morecambe Bay may be silted up, and converted into valuable marsh land. Nor could the process be prolonged to a distant date in so far as crossing the bay by a railroad were involved. From Lancaster to Wraysholme, by Warton Craig, the ground is highly favourable, and might be confidently expected to silt up in two years time, were the streams of the Ken and Keer diverted. When the tide-wave was checked in its progress, and had to float up an inclined plain on an exceedingly low angle, as much as 25 miles in length, and terminating imperceptibly upon a swarded ground; a filter so complete could not fail in speedily silting up the eastern regions of the bay, and thoroughly preparing the way for the reception of a railroad along the present favourable track at low water, between Slyne and Wraysholme. Should the green sward terminate nearer the present shore than this line, the difference to the railway would be trifling; and from Lindith to Wraysholme, which is about four miles across, might be confidently relied upon at an early date. We should purpose carrying the embankment and railway no further into the bay than a sward appeared. Material would be therefore obtained in every abundance on the spot. When the tidal force of the bay was broken by the ascent of a long inclined plain, strong works might not be called for, as proved by similar embankments on other arms of this great estuary; and of which Mr. Dawson's reclamations, on his estate at Aldcliffe Hall, adjoining the river Lune, is a distinguished instance; and a satisfactory answer that Morecambe Bay may be crossed by a railway on the terms here described, even at a trivial cost, without risk, or any inconvenient delay of time whatever. Indeed, from Lindith to Wraysholme, foregoing even the advantages of diverting the central land-stream at all, it is admitted that this portion of Morecambe Bay may be successfully embanked and crossed by a railroad. With a diversion of this stream, it would prove a most trivial affair.

Having disposed of the centre and main arm of

Morecambe Bay, the works which diverted and secured the Ken, from Wraysholme to Chapel Island, would serve a double purpose, and need requisite substance and breadth only to sustain a railway. From Chapel Island to the shore of Conishead, where it is proposed to cross the stream of the Leven by a viaduct, the foundation and means of construction are as favourable as might be. Indeed, the channel of the Leven might be temporarily thrown on the eastern side of Chapel Island, until the works on its western side were completed; and the practicability of crossing Morecambe Bay by a railway is shown to be a mere modification of effective and attainable plans maturely digested. Even the portion of the bay, which excites the most impracticable doubts in the minds of passing observers, might be probably formed at a lower rate per mile than any general line of railroad in the kingdom. Land would cost nothing. Raising no very high mound of sand with materials on the spot, and against which tidal action was completely neutralised, could neither prove doubtful, expensive, nor precarious. In what then does the impracticability of crossing Morecambe Bay by a railroad consist? In the idle notions of those who have never once contemplated the laws of tidal influence, and are prone to reject the rules and means of art and science. Entire means of turning the stream of the Ken around Chapel Island existing, and at a practicable expense, all the rest of the arrangements here proposed follow as plain consequences.

The vast waters of Morecambe Bay, in the hour of high spring tides, certainly fill the eye with a mighty instrument of physical force. Yet by cutting off a trivial limb of the bay only in the way described, its powers would be from that moment emasculated, and successful means of crossing it by a railroad insured on easy terms. Besides, many scientific men who have steadily reflected on the practicability of reclaiming Morecambe Bay from the sea have come to a favourable decision. Indeed, the project here developed is by no means a matter of doubt, but of certainty and sure success. Those who are adverse to carrying a railroad through Furness and western Cumberland may prove blind enough as a matter of prejudice and interest. Yet truth and national interests are sure to prevail in the end.

From Conishead, Furness may be crossed by a good railway through the vale of Lindal to Ireleth, which lies in a direct course. Here we arrive at the eastern shore of the Duddon, about which doubts cannot be entertained. The low weight of water, the means of silting up its western shore, from Burrow Crails, the excellent foundation which exists, and an abundance of the best materials on the spot, place this portion of the project in a settled light.

From Burrow Crails to Raven Bank, or from the western shore of the Duddon to the southern shore of the Solway Frith, a space of 62 miles in length, undulations and curves may be taken at nothing; on such a railroad, the delighted traveller might be wafted across the county of Cumberland in an hour and a half, or reach Carlisle in less than two hours. Facts so conclusive, prove the wisdom of turning the mountains of Cumberland, in preference to forcing the elevations and curvatures of mountain heights and mountain ruggedness, over and above the objections taken to long mountain tunnels. Twice the sum of money expended in construction, would be worked at more than twice the expense in propelling powers; more than twice the time occupied in travelling; higher chances of accidents and delays, and passing over a mountain wild, can never be a competing line with that which proposes to turn those mountains, without undulations, without curves, and without the boring of monstrous tunnels, on almost as short a line of railroad; providing for the wants of considerable towns, and a wealthy agricultural district over and above.

A railroad is certain to be completed on the line here marked out, regardless of the previous follies of any rival company whatever. From London to Dumfries, by the vallies of the Thames, the Severn, and the Weaver, with the plains of Lancashire and western Cumberland in continuation, leading across the Solway Frith to Tordiff Point, presents the longest chain of level ground and straight lines of which our island may boast. Not to say the wealth, the manufactures, the commerce, and marine affairs which lie upon and touch this great line of levels. Nor is this all.

Viewing the line here traced out as a common base to numberless ascending vales, a denial of our proposition, might seem a denial of all just rules of science and common fairness. For the Geological reasons assigned, central England ought to be turned rather than crossed, and its rugged undulations and sharp curvatures avoided as much as may be. Sooner or later such a principle of laying out national railroads must prevail in spite of any opposition which folly and selfishness may devise. In bringing these truths under public notice, we may fairly ask capitalists to pause ere they rashly clutch at shadows, and forego the substance more easily secured. If this language applies strongly, we but state what conviction believes to be true.

The practicability of crossing the Solway Frith from Raven Bank to Tordiff Point by a railway, having been already shown, we need further observe only that both these approaches are as favourable as can be conceived. Firm ground of a proper elevation close to the shore; the means of readily silting up the space of the Solway Frith, which lies immediately eastwards from the sea locks of the Carlisle Canal, is not less certain. It is no more, in the operation of natural laws, than adding a hair's breadth to depositions which originally abutted on Skiddaw, now distant twenty miles from the central bend of the Solway Frith. The material is besides already there, as the upper parts of the Solway are almost choked up by drifted sands. Nor is it less easy to turn the channel of the Eden, into the Esk, throw the compressed channel of those streams united on Tordiff Point, build a stout viaduct thereon, and cut a tideway through such a viaduct at once. Even the material obtained in cutting a new channel through the short space of Tordiff scar or point, would be of great service in forming the southern approach thereto; whilst the north approach rested on sufficiently elevated and strong ground.

With a fine tideway up the Solway Frith, a deep pool at its top, unfettered by any bar, all the essentials of a good harbour completed, and a trunk line of railway, combining the intercommunications of England, Scotland, and even Ireland, on this spot, the Carlisle Canal Company would unquestionably add a railway to the line of their canal, which would afford a level, straight, and short line of communication, without detriment to any town whatever. In short, the Solway Frith, crossed from Raven Bank to Tordiff Point, the rest would follow as unerring consequences. Moreover, in conveying the coal of western Cumberland to the south of

Scotland, it would shorten any other practicable route by ten miles; and give a central port to Newcastle-upon-Tyne, Stranraer, Glasgow, Whitehaven, Wyreton, and Liverpool, offering an equally eligible shipping town to our inland commerce and manufactures. What the channel of the Solway now is, makes no part of these conclusions. We have shown that a tideway may be obtained surpassing the Thames and the Mersey. Every scientific man acknowledges that the embouchure of the Wampool and the Waver is what renders the navigation of the Solway Frith notoriously bad and dangerous. The means of mitigating that objection is certain; and crossing the Solway Frith by a railroad from Raven Bank to Tordiff Point, not less so. For these we claim public attention and examination, and we fear not the strictest scrutiny which can be bestowed upon them.

The Geological structure of the south of Scotland demands our next investigation. Between Saint Abbs Head and Belford on the east, and Loch Ryan on the west of Scotland, an elevated ridge, chiefly composed of the whinstone of the secondary formation, bisects the island from sea to sea, and completely severs the chain of the two great plains that lie on the western and eastern boundaries of England. Every point of this ridge is difficult to cross by a railway, and the heart of Scotland lies on the north of such a chain of mountains. The most eligible pass through a ridge of whinstone so continuous, is by the valley of the Cree into Ayrshire. Here is the key of our plan. If a line of railway by Moffat, from Glasgow to Tordiff Point, were 90 miles; one from Glasgow to Tordiff Point, by Dumfries 100 miles; a third from Glasgow to Tordiff Point, by the valley of the Cree, were 130 miles, the superior levelness and general straightness of the last, might render the practical distance the most speedy in travelling; and embracing the interests of Annan, Dumfries, Kirkcudbright, Gatehouse, Newton Stewart, and Kilmarnock or Paisley in a trunk-line. Glasgow at the same time requires a communication with Stranraer in the direction of Belfast and Stranraer, with Newcastle-upon-Tyne, and the manufacturing districts of the north of England. Our plan reconciles each and all of those objects, and opens out a line of railway communications from Stranraer up the great Scottish valley of the Frith of Forth, as far as Edinburgh on the south, and Dundee on the north. Loch Ryan at the same time, as a place of refuge for sea vessels, and in the construction of a harbour has but few equals, whilst it constitutes a main pivot on which our plan turns.

The practicability of crossing the Solway Frith by railway at Raven Bank and Tordiff Point is unquestionable. But the author of these pages does not think it impracticable to cross the Solway Frith ultimately from Allonby on the side of Cumberland, to Southerness on the side of Scotland.

This route would lessen the distance to Cree as much as 30 miles; and render the line straighter and more level. It would not be difficult to speedily silt up the Solway Frith on the side of Cumberland; and from Allonby or Dubmill to Southerness, most of the water is already shallow and hard at the bottom. On Southerness the water is deep. But it might not be impracticable to make arrangements for speedily crossing such a navigation channel, say three miles in breadth or less, at all times of the tide, by a ferry apparatus, as deep water enough could be insured; and steam is a tug as well as a propelling force capable of ferrying over any burthen which a railway communication required. To provide for this possibility at a future date, a shorter, more level, and straighter line, by five miles, might be obtained from Annan to Kirkcudbright, by Southerness, than by Dumfries, crossing the navigation channel of the Nith by a ferry apparatus under great advantages; and thus shorten and expedite the route to Glasgow and Stranraer very materially. For though a little time were lost at the ferry in crossing a navigation channel, yet straightness, levelness, and a shorter length would more than compensate such loss of time. So that the practical distance from Annan to Glasgow would seem still more in favour of a line by Cree, also commanding Stranraer, in preference to either the valley of the Nith or the vale of Moffat. At the least, however, having taken a full view of the features of the south primary isle of Scotland, actual surveys may be confidently left to decide the most eligible plans to be adopted, always keeping in view practical distances, public convenience, and legitimate objects.

Such a scheme of railways for combining the intercommunication of England, Scotland, and Ireland, claims pre-eminence above all others. The several interests of the United Kingdoms are embraced in the cheapest and most speedy means of conveyance which may be devised. It rests all its main pivots on the chief ports of the empire. It purposes to take in most of the small towns, or admit of the most favourable construction of branch lines. It affords to large inland towns the best practicable means of communicating with the metropolis of the empire; and with our several ports. It lays down base lines upon which local railways may impinge the most advantageously. It traverses the various centres of our agricultural wealth; and offers to the extreme limbs of the empire, such as Exeter, Dover, Brighton, Southampton, Dundee, Waterford, Cork, Limerick, Sligo, &c. &c. the most direct means of intercommunication with their fellow subjects in all the industrial arts; and bonds of science, social order, and civilization, whether in the capital, provincial towns, or the rural districts; traversing as it does those vast delightful plains, which constitute so much of the agricultural wealth of the empire, and the solid basis on which the political safety of the country is securely laid.

A number of difficult transverse lines of railway are certainly required, and which are called for by the industrial wants of the empire. Fortunately, however, several of those transverse lines are either in progress, or in a fair way of receiving the sanction of the legislature. Such as the Manchester and Leeds Railway; the Sheffield and Manchester Railway; and the Leeds and Selby.

The train of reasoning already applied to the Great Western Plain, by Cheltenham, the valley of the Severn, and that of the Weaver into Lancashire and Cumberland, is applicable to the Great Northern and Eastern Railway. In short, the Eastern Plain is unbroken and continuous by Cambridge, Peterborough, Lincoln, York and Durham, to Newcastle-upon-Tyne, and capable of being traversed throughout at the rate of thirty miles an hour. Geology here points out a material defect, which the Eastern line has to contend against, in proceeding from London by that route to the Midland counties and towns. As the trending of the vales in this part of the kingdom is from north-east to south-west, so are they unfavourable for tracing from the metropolis, by a northern and eastern railway to towns situated like Northampton, Kettering, Market Harborough, Leicester, Loughborough, and Derby. Nevertheless, a line by the Northern and Eastern railway may be accessible to

Derby, and if to Derby from Peterborough, then by Stamford and Melton, also along the North Midland Railway to Leeds. Whether this be granted or denied, the same question arises along the whole line from Peterborough to York. Thus it is obvious that every opening from south-east to north-west across the ribbed ground of central England is likely to be sought out with a view of gaining lines of northern railway from the metropolis. We are aware that deep vales and rugged ridges are prevailing ground in the midland counties of England, excepting most of the area occupied by red sandstone. We are at the same time aware that general arrangements are broken by incidental fractures, which bisect those ridges occasionally, and afford openings through which railways may be successfully carried, from south-east in north-west directions, and of which the London and Birmingham Railway is an instance. In venturing on these remarks, a leading object must not be lost sight of, that we are more engaged in mapping out the main features of railways in England, in accordance with Geological events, than dealing in local details.

We trust that we have caught the leading incidents, which belong to the surface levels of England, and illustrated the general difference in expense and facility of travelling, between tracing diluvial and alluvial plains by railroads, and forcing the rugged aspect, undulations, and curves of the older formations by excavations, embankments, viaducts and tunnels. The newer plains may be generally traversed at one half the outlay of capital, one-half the annual charges in propelling powers, and in one-half the time. It has been inferred on these premises, what the just principles to be observed in the laying out of railroads are. The granite formation is generally inaccessible; and they seldom traverse the primeval beginning of dry land. The secondary formation may be somewhat more pliable. Yet it is difficult to deal with, and railways seldom do more than touch its borders. The tertiary formation, composed of carboniferous limestone, millstone grit, the coal measures, and new red sandstone is somewhat more pliable than the two older series. Still its general aspect is rugged and hard to manage. Yet its fossil products often cause branch lines of railway, and sometimes trunk lines within its boundaries. When crossed, the quartary series also is undulating, broken in its lines, and difficult to deal with. Diluvial beds are generally much more plastic than any of the older formations, especially on their lower borders, and where alluvial depositions have filled up all vacant spaces. Hence the lowest general level is that which is commonly to be preferred. Marine and alluvial deposits alone are easily formed, unless broken by arms of the sea, and intervening rivers. Here the silting up of estuaries, and the diversion of inland streams apply accordingly, as the weight and balance of prevailing currents decide, and applicable contingencies become available.

To these respective evidences we refer the merits of the subject in hand. In determining the direction of our national railways, the most difficult undertakings are the central districts of England; and the transverse mountain ranges of Scotland. Diluvial and alluvial plains are easily dealt with. Probably, the mode of connecting or not connecting the vale of Oxford with a general scheme of railways in England, is the most conflicting subject to be handled in future. It has level and tolerably straight lines. But do these apply generally or locally? Is it the best route from London to Worcester, coupled with the practical distance in time, and the expense of propelling powers by the vale of Oxford? Is it the best route from London to Birmingham? Or from London to Rugby? An excess of thirty miles in length may possibly be compensated by speed. Admitting the negative of these several questions, their strict scrutiny leads to sound information. Oxford has high claims, and surely those claims deserve attention.

Suppose that the great northern and eastern trunk line may be traversed from London to Newcastle-upon-Tyne in nine hours, and assigning three hours for going over the Newcastle and Carlisle Railway, the city of Carlisle may be reached in twelve hours from London, Dumfries in thirteen, and Stranraer in sixteen hours; allowing twenty miles an hour on sixty miles between Dumfries and Stranraer. On this scale of speed, Glasgow may be reached from London, by the valley of the Cree, in eighteen hours and a half, or in sixteen hours and forty minutes, by the line projected across Morecambe Bay. Such data shows that the competing powers of the northern and eastern trunk line, from London to Stranraer, outrivals the London and Birmingham line, and all but rivals the best line which may be obtained by a northern and western route, even under every advantage of traversing the basin of London, the vallies of the Severn and the Weaver, crossing Morecambe Bay, the estuary of the Duddon, and the Solway Frith at Tordiff Point. Granting that the comparative means of the western and eastern northern lines were equal in time of traversing, that is by no means a satisfactory reason why the western interests should not be prosecuted with the utmost vigour. A direct communication between the west of England and Lancashire, and between Lancashire and Glasgow is demanded.

Such a scheme of railways for England, Scotland, and Ireland, suggests the ready means of forming a line of intercommunication from London and Lancashire, to Glasgow and Belfast, by crossing the Solway Frith in steam boats from Whitehaven to either Kirkcudbright or Wigton Bay, or forming an improved harbour at Maryport, coincident with the flux and reflux of tides already noticed; yet certainly on very different plans from any that have hitherto been submitted to the people of Maryport. By running steam vessels from the southern shore of the Solway, to either Kirkcudbright or Wigton Bay, a direct communication could be speedily opened out between Newcastle and Glasgow, and between London and Glasgow, which might be traversed in sixteen hours, or to Valentia in twenty-six hours, by way of Port Patrick or Stranraer, and Belfast. In Wigton Bay, a deep water harbour could be formed, and 10,000 acres of land gained from the sea, similar in quality to Baldoon Parks, worth as much as £100. an acre. And the gain of the one would repay the expense of constructing the other; whilst the formation of a harbour, would render the reclamation of the land a matter of course. A railway from Ayr to Wigton Bay, forty-five miles in length, would even in the mean time, open out a direct line of speedy communication from London to Glasgow by Liverpool, and to Edinburgh also.

Hence the most speedy mode of connecting Linlithgow, Stirling, and Fifeshire with the metropolis, would be prepared for at a future date; rendering at the same time, every extension of railways on the western side of England, northwards, instantly available for Scotland—the Preston and Wyre Railway for instance; and fifty-five miles from Ayr would reach Kirkcudbright, immediately adjacent to deep water; and perhaps one of the most constructable harbours, in an unimproved state, to be found in Great Britain. The peculiar configuration of Scotland, and other incidents belonging thereto, leave no doubts as to the adviseableness of connecting Ayr and Kirkcudbright by a direct railway, as such a line is admirably suited for extension westwards to Stranraer, eastwards to Newcastle, and southwards into Lancashire by Whitehaven or Penrith. To let out Scotland in any other direction, the impediments to be overcome are desperate, and if practicable, such acquisition must be at a very remote date.

Bristol and Liverpool both lie on the western side of the kingdom and are ports to main sections of our population, with Wales on their western frontier. Manchester and other manufacturing towns also, demand a direct communication with the south and west of Scotland, and with Belfast by Stranraer. Hence the vast importance of turning the mountains of Cumberland on the west, and crossing the Solway Frith at Raven Bank and Tordiff Point by a railway.

Of all the English ports, Bristol holds a position which possesses the highest facilities from which railways may be constructed and worked. Continuous lines of deposition lead in every direction from the valley of the Severn. The national importance of the south-west divisions of England, cannot fail therefore in obtaining western and northern outlets by railways.

Bristol is placed in direct communication with London by the valley of the Thames, which communicates with Brighton southwards; Dover and Margate eastwards; Essex, Suffolk and Norfolk on the north-east; and as far as Newcastle-upon-Tyne and Edinburgh northwards. On the south-west, with Plymouth and Exeter by a direct line of railway; and the ground is favourable in the direction of Salisbury and Southampton. The valley of Oxford is open to the north-east, as well as that of the Avon, on a remarkably low summit level, into the valley of the Welland, which opens the way for a direct line to Stamford and the northern and eastern railway, or to the port of Boston. Opening direct lines of intercommunication by railway through those great vallies, between the south-west counties of England, and the northern and eastern counties. Again, the vale of Worcester opens into the valley of the Trent by Birmingham in one direction; and Kidderminster, Stourbridge, Dudley, and Wolverhampton in another. Affording also a direct line from Wolverhampton to Manchester, by Stafford, Stone, Newcastle-under-Lyne, Congleton, Macclesfield, and Stockport; while an easy branch line may be obtained from Stockport to Glossop, on the Sheffield and Manchester Railway. The open features of the ground from Bristol northwards into Cheshire, Lancashire, Shropshire, and Wales, have been previously described.

Geology sheds the purest light, therefore, on the science of mapping out lines of railway; and it is thus that railway construction illustrates Geology. The valley of the Trent opens the way from Nottingham to Hull, and Nottingham to York; and by such a route turns the Penine chain of hills, from Yorkshire and Lincolnshire, through Derbyshire and Staffordshire into Cheshire and Lancashire northwards, and the west of England southwards. Here the lowest transverse levels of England are obtainable, by merely tracing the lowest ranges of the red sandstone group, which cover such extended and continuous spaces, as the closing group of the tertiary formation, the link which binds together the various sections of England, and the ground which severs and cuts short the Penine ridge in Nottinghamshire, Derbyshire, and Staffordshire, throwing open in the very centre of the kingdom, the freest lines of intercommunication by railways. For while the fourth formation is commonly rugged and angular in form throughout, the red sandstone group is more regular, on lower levels, and straighter lines. Added to the spacious ground it covers, where connecting links of the kingdom are called for. For it not only turns the line of the Penine chain northwards; but the whole cretaceous range of hills southwards. Confirming our geological theory with the utmost exactness. The very channels along which the pine forests of a diluvial age have floated, now form obvious tracks which invite, and cannot invite in vain, the construction of railways. Profitable investments for capital at the same time, which may not offer a substance and yield a shadow, but remain for ever secure against competition. First, they traverse the most easy ground; they may be worked at exceedingly high speed; they may be cheaply propelled; they at once open out those industrial energies of England which are seated on and within the borders of the coal measures; they bring into direct and speedy intercommunication the ports of the Bristol Channel, which open the way to the western world, with those possessing a speedy access to the North of Europe; they concentrate the commerce of England on natural and fixed points; and they at the same time open out the vast agricultural and mining wealth of England. With such preeminent advantages, the ports of the Bristol Channel would seem to be entering upon a successful career of commercial industry, which can neither be denied nor withheld. Nature and science have alike contributed facilities of commercial intercourse, which lie palpably on the surface of future events, and cannot fail in casting momentous pages on the history of the world. Startling as these prognostications may appear, the proud reality may probably surpass the bounds of speculation in the projection of mighty national works, and deeds of scientific and commercial rivalry. A true map of geological combinations, exhibits Bristol as one of our main commercial centres.

Liverpool, to keep her place, must bestir herself in time. She must commence those great and important works on Formby Point, which promise to amend, secure, and facilitate the navigable waters of her Port. Those vast banks of destructive and obstructive sands, which endanger and impede her navigation, must be swept on the shores of Formby, into the estuaries of the Dee, the Ribble, and Morecambe Bay, until she enjoys deep and fixed water at all times of the tide. Liverpool need then fear no rivalry whatever. If her means of inland communication be somewhat more adverse than those of Bristol, she must repair the defect by practical energy and the application of enlightened science. She already holds a position in front of the manufacturing industry of England. She is nevertheless beset by obstacles and disadvantages, that it may be wise to repair before the golden sceptre of commerce, first trembles in and next drops from her hands. Morecambe Bay must be silted up and traversed by a railway. Its complete practicability is noways doubtful. The estuary of the Duddon must be dealt with similarly. Turning the mountains of Cumberland by a railway would then become plain, and an onwards task. Next, the Solway Frith, bestrode by effective works, on Raven Bank and Tordiff Point, would give a direct communication northwards to Glasgow, and westwards to Stranraer in a direct route to Belfast. And what is even more important, these several points attained, Liverpool would form the central pivot on which British commerce turned. Holding intercourse northwards as far as Glasgow, Edinburgh, and Dundee; eastwards with Manchester, Leeds, Sheffield, York, Hull, and Newcastle-upon-Tyne; and southwards with London, Birmingham, Bristol, Exeter, Southampton, Brighton and Dover. Liverpool is certainly in possession of pre-eminent advantages, which cannot be endangered, unless she falter in her allotted task. Placed in a vast theatre as it were, and on a stage which petty minds cannot successfully tread, noble daring alone can enable her to play her part well. But if, like some aged cripple, worn out and unfitted for further service, she neglects to renovate and strengthen her powers still further, she may be treated as an incapable, and superseded by more able and active hands. She has the lead, and must keep it, by continuing to exercise vigilance, energy, and skill. She must contemplate her true position bravely.

In dismissing the subject matter of railways in England, the uncalled for adoption of tunnels in some instances, and their unavoidable occurrence in others, are striking features in the planning of railways. Such distinctions are mainly decided by Geological bearings formed on the general operations of fluid action. From Berwick to the valley of the Trent, Glenwhelt is the only summit level which engineers have proposed to cross by a railway without a tunnel. To the south of this valley sectional summits from east to west seldom require tunnels, except for the preservation of straighter lines. A general difference so conspicuous, conforms to our theory with the utmost exactness, and is so applicable to the scientific formation of railways, that it gives a closing summary to this portion of our subject.

In Ireland, as well as in England, Geology is a true instructor on the best general plan of laying out railways. The Geology of Ireland is precisely the reverse of England in reference to the general surface and elevations of lines. Her primary Isles take a double line. Those of England a single one. England is therefore the highest, the most rugged, and inaccessible along its midland, from north to south. Ireland is the most level, from north-east to south-west, along its midland counties; and the most elevated and rugged on her north-west and south-east shores. Namely, on the side of the Atlantic Ocean; and on that of the Irish Sea. If Geology has thrown great impediments in the way of planning railways in England, it is not less so in Ireland. Her principal towns and ports chiefly lie upon her eastern and south-eastern shores. It is desirable that these should communicate with each other by railways; and yet the opening out of such lines would by no means afford a true base line for her national railways. The remedy, in principle, is obvious. Two distinct base lines are required. The one along her eastern and south-eastern shore. The other taking a midland direction. The application of the rule practically must be again modified in detail. The two lines may be occasionally worked into and serve instead of each other, and one made to answer the purposes of both. Whilst a shore line prevailed from Belfast to Dublin, an inland line might apply from Dublin to Limerick. Taking the direction of Kildare and Carlow, with a branch to Waterford. Such a line might thus serve the primary wants of Ireland; and would not supersede or prejudice those portions of a central line, which might be left for completion at a future day, and according to the industrial wants of the kingdom. Directed by the principle here laid down, the various railroads of the kingdom ought to be either longitudinal and general, or local and transverse lines in detail. Even communicating with each other in squares, as incidents decided. The rule on which all additions were to be made would then preserve an orderly scheme throughout, though completed in parts only.

In the application of such a scheme of railroads in Ireland, were a line from Belfast to Dublin, carried by Newry, Dundalk, and Drogheda, it would perfectly conform to the general plan. Suppose a line were completed from Drogheda to

Longford, local objects would so far agree with a general plan; and a line might be constructed on our previous terms from Londonderry through Tyrone, Monaghan, and Cavan, until it reached the Longford transverse line, which would conduct it on the base line of the eastern shore to Dublin. In case the centre base line were completed, a direct line would be obtained from Londonderry to Limerick. In a similar manner, Donegal and Sligo might also communicate with the other chief towns of Ireland. Let us further suppose that a branch of the Londonderry railway run to Armagh, and transversely to the base line of the shore, Londonderry would gain a direct track to Belfast. Nor would such a line of railroad compromise the true interests of Armagh, but uphold them. If a branch were brought from Galway upon the centre base line, Galway might communicate with Dublin by a transverse one, and the shore base in continuation. In a similar manner Galway, by the centre base, might have access to Londonderry on the one hand, and Limerick on the other; and by transverse and base lines continuously to Belfast or Waterford. Ennis, also, might enjoy a choice of open communication on all hands.

Cork, Kinsale, Bantry, and Valentia Isle, might each and all be accommodated by extension lines at any time, and by the easiest attainable routes. Every section and shore of Ireland would therefore enjoy the advantages which railroads could bestow upon them. It is also obvious that those high facilities of commercial, civil, and social intercourse may be generally diffused through Ireland by laying down a supposed base line along the eastern shore, and a central base parallel thereto, with connecting transverse lines at intervals. The centre base running from Armagh to Limerick, and the shore base from Belfast to Dublin, providing for the south-east section of the kingdom according to the most attainable plans.

Would a scheme of railroads for Ireland so framed afford profitable returns? We answer that it would. The sum of its population, combined with a concentrated plan of railways, could not fail in bringing so inconceivable an amount of passengers thereon, as to afford a satisfactory answer to the question here put. Ireland has 8,000,000 of people. All would partake of a comparatively easy access to those great national outlets, the industrial arteries of a common circulation, which operated in every direction, and to the very extremities of the kingdom, like unto animal life containing a complete system within itself, worked from the centre and diffused latterly throughout. Adequate returns would therefore obviously follow. All doubts about remuneration vanish, when right forms are hit upon, and the question at issue stated on its pure merits. Thus 230 miles of railway would complete both the base lines. Belfast and Dublin estimated at 90 miles, and Armagh and Limerick at

140. The shortness of these lines, and the prodigious effects produced on a population of 8,000,000, are plain considerations. Irish railroads might be worked from a common centre, and every part thereof operate in unison with its other parts. In England the matter is very opposite. Her railway scheme is obviously broken into fragments, which isolate the parts, and multiply the expense of construction exceedingly. Because the Penine chain of hills renders a central line inaccessible for general purposes; whilst along the Geological centre of Ireland, railroads may be carried on with railroad speed.

As a political consideration, a general enlightenment of Ireland would follow. The wants of one section of the kingdom, might be supplied by the industrial excesses of others. Civilization would then subdue barbarism. Profitable employment, adequate means of subsistence, and public confidence would be certain to follow. Population, where too dense, would diffuse itself, and become denser where profitable employment prevailed. An amendment in the social condition of Ireland cannot fail to awaken the attention of the British Legislature before long. Energy might then be applied to a grateful soil, and plenty reaped therefrom, by an industrious, contented and loyal people. For surely a nation governed by free and just laws, and prosperous withal, could not be discontented and disloyal. Social intercourse is the true cement of political union and peace, and could not fail in awakening the best and most cordial sympathies of our sister isle; twins in commerce—twins in nature's primeval works—twins in freedom without licentiousness—and of the supremacy of law without despotism—England, Scotland, and Ireland are inseparably linked together in social bonds, and the dearest sympathies of the heart divine.

Viewing the laying out and construction of railroads as a subject of national interest, England is obviously bound to adopt the highest and best mechanical powers known. In possession of the foreground of Eastern and Northern Europe, in the very gap which leads to widely spread and fertile plains, and enjoying the lead in vocations which depend on cheap coal, her conspicuous station among the nations of the earth, which these various advantages confer upon her, cannot be upheld unless she avail herself of industrial means which arts and science, commerce and capital call into active use. Though railroads worked by locomotive powers, and steam navigation are but recent contributions in aid of productive industry, yet they absolutely demand a speedy adoption of all the facilitation and cheapening of labour they afford; lest the sun of British industry should wane, and set to rise no more. Good harbours are also necessary adjuncts to those new and wonderful instruments of active industry, as the national termini and starting places to and from which railroads and steam navigation may appropriately go. And as arms of the sea and estuaries often cut off the best and most direct lines of railroads, so the most ready and skilful mode of reclaiming these from the sea, embrace a leading branch of our subject. Viewed in this light, Geology becomes of momentous importance, as a basis on which these considerations in some measure depend.

Nor is it less essential that our acquaintance with the art of laying out railways should be accurate and just. Error on this head may lead the way to great confusion and sacrifice of public and private interests. Railroads in the infant stage of their adoption were but ill-constructed; and being private property for private objects and purposes, often limited in the choice of ground, the undulations and curves necessarily adopted were striking defects in the practical system of a former day. Nor were the physical laws which determine the speed and economy of locomotive power, on its first adoption, sufficiently ascertained. Important data in these respects have been at length acquired, not with so much exactness, perhaps, as theory aspires to, yet accurate enough for practical ends. An ascent of twenty feet per mile, on a well constructed railway, or a rise of one in two hundred and sixty-four, may be said to double the propelling power required to draw any given load upon a dead level and in a straight line. Next, a curve even drawn on so favourable a radius as three miles, may be said to triple the space of time required to traverse a straight line. It may be said to add the length of the radius to the railway, and the rate of speed may be taken as reduced one half, or from forty to twenty miles an hour. Consequently the radius of such a curve adds twice its length to the practical time of traversing a railway on a straight line. On a level, and in a straight line, forty miles an hour may be accomplished in safety, and with due economy in the wear and tear of machinery and rails. Admitting this data to be assumed, yet it is sufficiently accurate for every purpose of practical illustration and demonstrative argument, in as much as it exhibits the detriment sustained by gradients and curves.

Comparing this data with the laws of traction on an ordinary turnpike road, throws great light upon the principles of laying out and constructing railroads. On an ordinary road, the propelling power required to draw any given load on a level, by a horse and cart for instance, may be taken as doubled when an ascent is one in twenty, or at the rate of 264 feet per mile. It follows from these premises that ascents at the rate of 20 feet per mile on a railroad may be much more objectionable than ascents of 264 feet per mile on an ordinary turnpike road. Undulations on this rate of ascent and descent upon a road, if not long ones, would neither materially add to the time occupied in travelling, nor impair the energies of the draught horse employed. In the application of double powers for a short distance, and gaining relaxation down hill correspondingly, the horse needs scarcely slacken its pace on the whole distance traversed, nor would he sustain perceptible injury more than on a level road. On the contrary, continual undulations of twenty feet per mile on a railway, might reduce the practical rate of travelling from forty miles an hour on a level, to twenty miles an hour on ascents and descents with such gradients. A loss of force would be therefore sustained equal to one-half the propelling powers employed, and double the time of transit required on a level and straight line. We so far learn that an ascent of twenty feet per mile on a railway may be more objectionable than a rise of two hundred and sixty-four feet per mile on a turnpike road. The importance of the most favourable lines of railway being adopted, which a country admits of, is so far distinctly shewn, and unanswerable.

Suppose an ordinary road to be made a turnpike, and having a series of undulations at the rate of one foot in ten ascent, or a rise of 528 feet per mile, the various ascents would then require the draught-horse employed to apply triple his usual powers as compared to a level road. The detriment would now be obvious, and might cause a delay and loss in travelling equal to twice the time and expense of traversing a level. The result of these terms are, that a railroad rising and descending continuously at the rate of 20 feet per mile, is as detrimental, comparatively, as rises and falls on an ordinary road at the rate of 528 feet per mile, admitting the balance of carriage in all cases and both ways be equal. Nor is this a matter of theory. On a level, and in a straight line, travelling at the rate of 40 miles an hour is admitted by Engineers as a practical rule. Mr. Stephenson, in reference to speed, estimates the comparative rate of travelling on the London and Birmingham Railway, at 20 miles an hour only. Consequently, the gradients and curves adopted in this line of railway, give a sum of practical objections equal to repeated undulations of 528 feet per mile on a turnpike road. According to the rule by which we should say, that the one was a hilly and a bad road, should we say that the other was a highly objectionable railway; and we have Mr. Stephenson's authority for saying so. Certainly, we by no means impute such defects to a want of engineering ability, but to the ground traversed; unless the chalk formation in Oxfordshire and Buckinghamshire had been ably turned, or boldly cut and tunnelled. Railway construction may be classed as an almost infant science, applied for local purposes, sometimes under great disadvantages, and deficient in facts and rules of art. Even Mr. Telford, a name distinguished for ability among the engineers of his day, planned the Cromford and Peak Railway, unfitted for travelling at the rate of more than four miles an hour. In the application of infant science to those great works, Engineers adopted comparative language, and reported this or that project favourable, or unfavourable, according to what had been done before in other instances. Reports were so justified by defective experience; and such railways as the Cromford and Peak, the Liverpool and Manchester, the Newcastle and Carlisle, and the London and Birmingham, have had the sanction of eminent Engineers. Railroads, it is true, had been applied to limited ground, rather than the best attainable lines. While merchandise was conveyed from place to place by pack horses, and on track ways, undulations in the way were immaterial, and preferable to swamps and soft ground in a state of nature. These tracks in time became the routes of turnpike roads. Then the errors of a former day became manifest. Hence it has been found advisable to reduce hills, where practicable, having a rise of one in ten, to less than one in twenty. Yet the correction of a defective system has been apt to involve turnpike trusts in debt, without adequate funds of redemption. Consequently, depressing rent-charges are saddled upon our turnpike roads, which are both obnoxious and adverse to that cheapness of production, which might have obtained, had corrective measures been resorted to at a more early date. In laying out turnpike roads, in our own day, science often suggests the advantage of rounding undulations by more level base lines. Twice the distance may be preferred in some instances, therefore, where a rise of less than one in twenty may be readily attained, and when a rise of one in ten might be expensive to reduce materially. The skilful laying out of turnpike roads is an arithmetical estimate of benefits and objections balanced against each other, and decided by contingencies. More easy undulations, at a trivial sacrifice of length, may be adopted with perfect propriety under given circumstances. So recently as sixty years ago, in laying out public roads, straight lines were preferred, by Commissioners of Inclosures, with acclivities of one in ten, to easy curves of one in twenty. The consequences have since been either throwing such roads idle, and making fresh lines on more scientific terms, or reducing the ratio of ascent to easy gradients.

Similar rules of science apply to the laying out and construction of railways, in conformity to the principles of traction, and incidental circumstances, justified on grounds of public utility. The same claims of public wants and benefits, which sanction legislative enactments for railways, may induce rival capitalists ere long to apply for and obtain acts of Parliament, which will throw the imperfect works of a ruder state of science idle. In the projection of railroads and the passing of such bills through Parliament, it is scarcely asked in how much they interfere with canal interests.

A course of events demanding higher facilities of conveyance having come to pass, a consideration is seldom cast on the protection of previous monopolies. Rude attempts at the construction of imperfect railways, must therefore give place to public necessities enforced by a purer state of science. When cupidity perverts the best interests of the public, when prejudice overrules just measures, and pliable engineers sell common fairness for gain, suppressed incidents are sure to assert their fair claims in the end, and bring about days of retributive justice. Such follies must then lose all influence in Parliament, and railroads be carried along the best deviseable lines, altogether regardless of previous monopolies and mistakes.

It is obviously true in theory, and no less correct in practical operations, that an undulating railway exceeding an ascent of 10 feet to a mile, must ever descend in a jolting manner, and ascend at a diminished speed; so that a railway having declivities and acclivities at the rate of and exceeding 20 feet per mile, can scarcely do more than maintain a speed of 20 miles an hour, compared to 40 miles an hour on a straight line and a dead level. Nor are curves less objectionable in a given degree than undulations. They retard speed, multiply danger, and tear the rails. Consequently the greatest care is called for on the part of the legislature in securing to the public the best attainable lines of railways, as it is those interests alone which justify the invasion of private property for public benefit.

In laying out the Newcastle and Carlisle Railway, on the side of Cumberland, the interference of the Earl of Carlisle, or with more truth, some of his agents, opposed the best line which might have been taken. A high viaduct was consequently built at Corby, under the sanction of Mr. Howard of Corby Castle, and a uniform ascent of the railway from Carlisle to its summit precluded. We are now to consider the remote consequences of an oversight on the part of the Earl of Carlisle, and the liberal spirit of Mr. Howard.

An undulating line of railway is about to be laid down from Maryport to Carlisle. A bad railway must therefore be formed from Maryport to Greenhead, the summit level of the kingdom. Time is sure to amend these obvious defects, or lead to their mitigation in no inconsiderable degree. A new company may propose to lay down a better line of railway on the north of Carlisle, which may be traversed in one half less time, alleging, very truly, that their natural interests have been compromised. A line so taken would obviously draw away the traffic of the present railway, inasmuch as its formation would be cheaper, more speedy, and worked by less expensive propelling powers. Moreover, it would not only command the route from Carlisle to Whitehaven, by crossing the river Ellen at Rockcliff, but from Greenhead to Whitehaven and Dumfries also. The Newcastle and Carlisle, and the Maryport and Carlisle Railway Companies, are therefore certain to be either driven to amend the false directions of their respective lines, or ultimately incur the ruin of their property. First, the level of the Corby viaduct should be carried on nearly a straight line from thence to Dalston, avoiding an undulation of 62 feet in a space of six miles only, and more real length, besides curves, which more than double the practical distance, or augments the working powers of the railway equal to seven miles in length. Again, from Wigton to Maryport an undulation of 120 feet intervenes unnecessarily. To remedy a defect so fatal to the interests of this line, it ought to descend from Wigton, and impinge upon the great trunk line into Scotland. These additions would complete the best obtainable line of railway from Whitehaven to the summit level of the Newcastle and Carlisle Railway at Greenhead, and save an hour and a half of time in performing the journey. There is besides a still stronger inducement for the Maryport and Carlisle Railway Company making such an alteration. A line from Maryport to Tordiff Point, would open out a direct communication to Carlisle also, which might be traversed at the rate of 30 miles an hour, in place of 20 miles an hour by the Aspatria summit, which is 172 feet above the level of the sea, and pestered with objectionable curves, from which a low level would be free. Nor would the speedy line exceed in real length the slow one. We may fairly ask, why has a line so defective been adopted? Because the shipping interests of Maryport sought additional customers for their harbour, and because the coal-owners of the valley of the Ellen sought to get their commodity more cheaply and speedily to market. Hence the Maryport and Carlisle Railway has been converted into a local line for individual and local purposes, in place of its forming a portion of a trunk line from sea to sea, and to Tordiff Point. They have accomplished their purpose; and it is certainly just that shareholders, who have borne out the measure with open eyes, should participate in the final consequences which are certain to ensue unless redressed. But we feel sure that they will be redressed when a day of future necessities arrives.

It may be said that gaining one hour and a half of time, in going from Whitehaven to Newcastle is not material. We think far otherwise. Suppo sean average journey to occupy six hours by an imperfect chain of railway, and that four hours may suffice by a good one, the merchant of one town may visit his friends in the other town, transact business, and return home again in a day. Not so by a slow line of railway. Twice the loss of time, and twice the expense of travelling must be incurred in the one case, compared to that of the other. A like argument applies to the speed of railways in general. Economy of time and expense are leading principles in their utility, and a main cause why they may prove successful or unsuccessful speculations. We should, indeed, like to know the proportion of passengers that go by the Liverpool and Manchester railway in a day and return again. Proving beyond the possibility of denial the advantages which the best lines of railway possess over the most ordinary ones. On this principle a line from London to Liverpool by Birmingham, could be no competing line with the best obtainable one from London to Liverpool by Worcester. Nor could the present undulating line from Liverpool to Manchester be a competing line with the best which might be constructed, and is, therefore, likely to be constructed. Truisms so imposing are surely worthy of attention on the part of capitalists and the legislature.

On a dispassionate review of what has here been said, Parliament would seem remiss in duty should they withhold acts of parliament for amended and superior lines of railways. Public interests demand the best lines. It is a main principle in their justification. For the invasion of private property can be made in obedience to public necessities or important conveniences only. An admission so comprehensive might in some measure operate in deterring men from an undue invasion of public rights. If legislation in favour of railroads be called for by public utility, the same principle which justified its commencement justifies its continuance, the repairing of mistakes, and a correction of private vices, in favour of public benefits. Nor could any corrective prove more salutary than an admission so general and equitable in its tone. Going from town to town is certainly a sound rule. Carrying base lines along our vast plains by no means appears less so.

If it be assumed that the Earl of Carlisle in withholding from the Carlisle and Newcastle Railway Company facilities he might have conceded to them, occasioned an unnecessary elevation of the Corby viaduct, and a disadvantageous ascent on the line of road, the public have a right to repair such error as far as may be, and of those who have fallen into similar mistakes, by commencing a gradual ascent on a low level, should a western and northern Caledonian railway cross the Solway Frith at Tordiff Point, which impinged upon that line as much as 20 miles to the westwards of the Corby viaduct; converting by such means private oversights into public advantages. Whilst this scheme of railways in Cumberland shortened the journey from its western ports to Newcastle one hour and a half, it would also facilitate the communication of the west with Carlisle, and correct the plan of the coal-owners in traversing the valley of the Ellen, imparting to the county of Cumberland all those industrial benefits which may be fairly contemplated from railways. If the coal-owners of the east and west of Cumberland have promoted plans which appeared to favour their particular interests, it is just that public interests should not undergo neglect. Those parties have entered upon public works that cannot be relinquished, and in favouring a full developement of railways throughout the county, they would act as wisely for themselves as for the common weal.

We have previously admitted the difficulties of laying down railways in the west of Cumberland, owing to the coal-field of the valley of the Ellen being severed by a high range of red sandstone, from the low level of a diluvial plain on its northern border. We have advocated, therefore, that general base line through the north-west of Cumberland, the principles of which has been applied in these pages to the kingdom at large. The advantages of the principle are obvious. Lines carried up the various ascending vales of the whole kingdom may then impinge upon common outlets for all; and reconcile as much as may be the obstructions occasioned by the high levels of the midland districts. If first steps have been inadvertently undertaken and in detail, instead of marking out an original plan on general base lines as here suggested, that by no means affects the final working of a system which cannot stop, and must now go on from a disfigured beginning, until an organic form appears, under the guidance of intelligence and design, like a new system within itself, or a new universe planned and carried into effect by man. Oversights corrected in detail, the true interests of the nation would cause order and form to take effect on general grounds.

For instance, the coal-owners of the valley of the Ellen have neglected their best natural customers on the south of Scotland. By a bad scheme of railways they have placed themselves 32 miles from any accessible route to those customers, and cut themselves thereby effectually out of the market altogether. Whereas a western and northern Caledonian Railway, crossing from Raven Bank to Tordiff Point, by an easy branch to their coal-field, the distance would be reduced to 15 miles of the most favourable railway, worked by one-fourth the propelling powers on a line of 32 miles. Indeed, with an infatuation which seems incredible, the coal-owners of the valley of the Ellen, by the plans adopted, hold out to the Newcastle and Carlisle Railway Company a strong inducement to construct a direct line from Corby to Dalston on an easy descent, and supply the country with coal as far westwards as Wigton even, since, in competition with an opposing acclivity, the descent would be a general one. Nor is this all. A main error in the Newcastle and Carlisle Railway would thereby be rectified; and in so much the best possible attainable overland railway would be completed, should the descent impinge on the trunk line of a Caledonian Railway. The disjointed plans with which those several railways have commenced, are therefore likely to work themselves into perfect order and form, under the able hand of public intelligence, the stern hand of public convenience and public rights.

On an eastern section of the Newcastle and Carlisle Railway another vital error needs correction, and is therefore sure to be corrected in time by the potent sanction of Parliament. A railway ought to traverse the northern line of the river Tyne, on the summit level of the North Shields Railway, with a junction tunnel. The northern line is an exceedingly eligible one—would let out the coal-field on the north as well as the south—(and why should not this be so?) and save fully half an hour in time. Saving on the whole, by the improvements suggested, two hours of time in travelling from Whitehaven to Newcastle—a most momentous consideration—supposing a competition line to Stranraer in the way to Ireland be admitted overland.

If the arguments here given on local grounds, be viewed in the light of generalizations, which affect the laying out of railways in the kingdom at large, we submit that the real merits of these extended projects are somewhat aptly illustrated. Averse to entering into details which involve personal considerations, we have endeavoured to argue the question abstractedly, which embraces crossing the kingdom on its narrowest accessible points, by chains of railways, resting on Whitehaven, Stranraer, and Tordiff Point on the west; and Newcastle, Gateshead, and North and South Shields on the east. And though we may not have altogether avoided personal considerations, yet practical examples appeared requisite to abstract illustrations, which apply generally, and to the kingdom at large. In truth, railway questions have become a species of social warfare, involving alike prejudice and selfishness, private cupidity and individual scheming, coupled with the vital interests of the nation at large.

Under circumstances so influential and comprehensive in their bearings, surely Parliament must be thoroughly convinced that our national railways ought to be framed on general plans that coincide with public interests and attainable objects. As matters go in the mean time, there is a pardonable tendency to carry base lines either along or through our various coal-fields inapplicably, and detrimentally to the nation at large. A good railway for general purposes can be rarely applied to such ground. It is too rugged and angular in form. Undulations, curves, and tunnels are therefore sure to be encountered too frequently. Besides, large towns are either mainly situated upon our coasts, or on the banks of considerable rivers. Population is therefore seated on plains mostly, and at some distance from coal-ground, which is commonly met with in more inland and elevated districts. Railways for the conveyance of coal ought to depend more on branches therefore, impinging on the main lines of the kingdom, which carried even coal itself to a distance at an easy expense. The scheme of railways here described on the best eastern and western northern lines, illustrates the view here taken somewhat fully. They would neither of them pass through the centre of a single inland coal-field, yet occasionally skirt them, and ever afford ready facilities for descending advantageously on lower levels. Much less national capital would be subtracted in carrying such a scheme into effect: it could be worked by cheaper powers—it would dispense with objectionable tunnels—it would serve the proper interests of our towns more effectually—it would afford higher facilities in travelling—it would accommodate a large portion of our population with means of travelling—it would promote agricultural enterprise—and convey the various products of land to markets and towns more speedily and cheaply. On each and all of these grounds it recommends itself to public attention. More profitable, gaining more customers, and seldom limited within narrow vallies, a choice of ground is afforded, which interferes less with gentlemen's seats and parks. It may be asked, why does such a scheme not recommend itself? We answer, the general interests here advocated are isolated and broken as a whole. On the opposite, coal-owners are a wealthy and concentrated body of men, in possession of considerable individual influence, and with great personal interests at stake;—somewhat prone at the same time, in resorting to an excess of policy, to overlook higher and more permanent interests, while momentary objects are promoted.

At a time when railways have become so important to the true welfare of the British empire, and when excessive confusion thereon is likely to continue, unless comprehensive and applicable plans are laid down and acted upon, it has become a paramount duty on the part of government to obtain all the requisite information on the best modes of laying them out, and according to an enlightened and general scheme. Hitherto the construction of railways has been all but rude and barbarous knowledge, so far as true science is concerned, and the application of just rules in laying them skilfully out; because sufficient experience and a body of essential facts are wanting. If shareholders err, the true duty of Parliament is to let them suffer, when public convenience and welfare are the questions at issue. Whenever the protective shield of the Legislature is thrown over defective works, encouragement appears to be held out for new companies to start in the path of error, under an expectation that Parliament may in future justify the wrongs committed. The worst consequences ensue. Instead of listening to canal interests, the main question to have been asked, on the laying out of the Liverpool and Manchester railway, is the best attainable line preferred? Finally, the best attainable line is sure to be adopted. Public interests are likely to demand and gain those demands in future, by the same sort of struggles which have given them the facilities of a railroad.

Granting that we push this principle somewhat far, for we admit that settled claims ought to have priority of hearing, and favour shown them as the greatest of all public rights, yet it by no means evinces less folly in committing the laying out of railways to infatuated shareholders and interested Engineers. Any body may see at a glance, in what has been said, that the evidences which justify a railroad are mainly incidental in reference to the actual necessities and conveniences of commerce and the people. These, at the same time, may be strictly mathematical questions. The real length of any line of railway by no means decides what we choose to call the practical distance. It is an item in the terms under which the entire question may be placed. The means of speed is as truly a balance to length as fluidity in physics is a balance against density at rest in a simple question of preponderance in physical forces. Hence the practical distance claims the strictest attention, in as far as it stands opposed to real length.

It has become the inalienable and bounden duty of her Majesty's Ministers, as the organ of the state, and the conservators of public interests, to institute an inquiry into the best way of laying out railways in England, Wales, and Scotland, similar to that of which Ireland enjoys the benefit. A national survey and levelling of the main water-course and water-shed lines, is, perhaps, the most of what is required at their hands. The sum of expense ought not to delay national objects so vastly important. The Geological surface of Great Britain lies before us ready mapped by nature to our hands. A few summit levels and leading undulations and curves, in addition to information already possessed, are all that are now to be required. Any survey in detail would be uncalled for. General information collected and embodied together, with trivial desiderata supplied, might be quite equal to the framing of a general plan. Impassable obstructions and their extent ascertained, attainable lines and the spaces they occupy made known, so far as general lines were a question, the various ascending vallies of the kingdom would naturally develope themselves. None can deny the existence of an eastern and a western plain; and the facilities and obstructions met with on those plains are equally obvious. None can deny the undulations and elevations of the midland districts of England, and their generally inaccessible features. The basin of London is not less apparent. The vale of Oxford resolves itself into a small space. The valley of the Severn is apparent, so are those of the Trent, the Welland, and the Avon. Hence a large mass of valuable information might be readily obtained, and placed in consecutive order.

National railways are demanded. They are, indeed, in progress on an immense scale; and shall they have no common links of combination, except those which accident bestows? If the welfare of a whole community demands an invasion of private property, it is idle to permit that invasion on other than public grounds. Hence a national survey and an enlarged scheme of railway ramifications have become exceedingly urgent, and not to be any longer delayed. Under present circumstances supineness leads to grave errors. One man's property may be needlessly invaded. Is that just? The capital of another may be wiled from him by untrue representations. Can that be justified? Public convenience may be neglected by one party, and another party may commence a repair of such injuries. Confusion is, therefore, eventually worse confounded. Is this a state of things to be endured in a free and enlightened country? Surely not.

Organization is the great law of intelligence divine. It is a law of free and safe government in social communities. Comprehensive systems can never spring up incidentally. They must be trained by intelligence. Deliberate observation and contemplation body forth great plans, and provide applicable details for all their most minute parts. On the opposite, accident disfigures whatever it touches; and it is supremely ridiculous to trust the laying out of national railroads to disjointed and isolated bodies of men. It is certainly an erroneous policy to interfere too much with individual action and energy; but it is not less erroneous to leave them to themselves altogether. An organic system of our national railroads is called for at the present juncture; and it behoves her Majesty's ministers, as true organs of the state, to repair defects in a discreet and statesmanlike manner. Not by flying into extremes, but by walking in the path of plain dealing, and necessary interference alone. Although we deprecate a Government which is too meddlesome, and would admit a broad latitude to public and private action, yet non-interference in the framing of general plans may be highly objectionable, and lead to deplorable consequences. Railways appear a case in point. Whilst every facility were given to their necessary construction, and the formation of private companies for carrying them into effect, yet those companies ought to be kept within due bounds. Secured thus far, self-regulation might then be safely and fairly conceded.

Nor does it yet appear too late to frame an attainable scheme of proper base lines, upon which local railways may advantageously impinge. Were

Geology illustrated by a few water-course and water-shed levels, along with other requisite facts, the ground on which general lines might be carried, could be speedily ascertained. London and Bristol have a line of railroad communication already fixed. Bristol and Liverpool require the same sort of facilities. Liverpool and Whitehaven claim attention, and the best line of communication also in continuation to Stranraer and Glasgow. On the eastern side of the kingdom, railroads appear to be progressing on satisfactory plans from London to Cambridge, Lincoln, and York, to Newcastle-upon-Tyne and Carlisle. Though the duties of Government are by no means of an onerous description, yet their interference seems called for, and exercised forbearingly and discreetly. Dictating so far as control applies, and leaving free that which may be safely and beneficially left to individual hands, for the common benefit of the nation and the profit of private companies.

CHAPTER VII.

ON THE APPLICATION OF GEOLOGY TO THE QUALITY OF LAND.

FRUITFUL and sterile land, taken in a comparative sense, has been originally determined by the laws of Geological deposition. The results are apparent in every stage of the earth's progress towards existing appearances. Dense and sluggish particles of matter, which are probably laminated or flattened in their atomic bases, and cease to roll about so readily, from that cause alone, as those which preserve a more spherical and divisible form, are necessarily the first deposited by the operating principles of universal fluidity, and brought to a state of natural rest. These may be denominated the least active atoms of matter, merely owing to their being bruised or flattened. Driven into little masses from this cause, they consequently lose that fluid activity which contributes to keep them in motion. Spherical atoms, owing to a difference in form, necessarily remain more finely divided and active, and have a less tendency to take a state of repose than such as are flat, dense, and sluggish. To speak somewhat figuratively, they are more idle and unfitted for the purposes of organic action, and working smoothly in regulated forms.

An atomic theory so familiar may be aptly illustrated by the travelling beach on the English borders of the Solway Frith. The tidal current in flowing up the estuary has driven a bed of rough shingle before it, that underwent deposition within the boundaries of the channel. Sand being more rounded and finely divided, having a less tendency to rest upon an accumulating beach, was naturally driven around its extreme point, and finally deposited in more still water. Finely divided clay, also, being more active than sand, was by a similar law propelled more forwards, and deposited on a base of sand. Vegetable and animal remains, which contribute so much to the fruitfulness of land, had a still less tendency to deposition, and finally took rest on the surface of the whole. The fertility of the soil in the Low Holm, though of a common origin, differs from such causes materially in quality. The ordinary laws of fluidity and deposition having mainly contributed to assort the various particles of matter, of which the soil is composed, and different degrees of original fertility prevail, accordingly as their density and lightness have determined the order of deposition.

We so far observe a material cause why soils of a like origin, may at the same time differ materially in the constituent proportions of matter, and in natural fertility also. In one the proportional composition of sand may be in excess, in another fine clay, and a third may be too much composed of vegetable remains. Again, as finely divided lime is scarcely a component element in these marine formations, we ascertain a defect which might have been corrected. Notwithstanding these differences in the quality of land in the Low Holm, a kindred resemblance obtains which may be readily traced to a common geological origin. Of course, this class of land occupies a low level. Seldom so much as ten feet above high spring tides, often within their level, and even where the best land is situated, defended by embankments.

A defect in the land of these plains arises from the low level on which they lie. An even surface contributes to the retention of water, on the supersoil in the first place, and next in the subsoil. The elements of chilling dews and fog are, therefore, generated, that either occasion diseases in plants, or exercise a withering influence, and lead to blights. The climate also being damp, crops are liable to sustain injury from excesses in temperature; cold more especially. Effective draining, which purposes to draw off an excess of dampness from the soil, points out an efficacious remedy for natural imperfections; contributing to remove the baneful influence of stagnant water from the surface, it gives land the firmness required for bearing cattle in wet seasons, and corrects those chilling dews so apt to occasion mildew in wheat, and other diseases in grain crops to which soils on so low a level are liable.

The next class of deposits met with on the plain of Carlisle, or western Cumberland, is composed of diluvial clays and sand, ascending from ten feet above the level of the sea to an elevation of one hundred feet. We here again notice a common Geological origin in which a considerable difference in the quality of land is detected. Nor does this difference rest here. The application of art has brought about changes for which nature has prepared the way. Not more than three centuries ago, mills have been erected, at intervals, for grinding corn, upon streams which descend from high levels, and through intermediate vallies. Whilst a state of nature decided the deposits of those vallies, and where descents were found which afforded adequate mill streams, the repeated ravages of land floods appear to have covered most of the adjacent land with gravel and sand to a considerable depth, and upon its surface. There are to this day full evidences remaining that when the requisite bays had been constructed for acquiring mill streams, and land floods were checked by such means in their descent upon the low lands, the intermediate spaces of smooth water so produced, promoted an accumulation of sloughy earth, and covered these vales from three to five feet in thickness with a fresh order of depositions. Art still more modern, has applied under-ground draining to these vallies, and land highly fertile in quality has been by such means obtained.

Another class of these vales, the seat of land springs, less subject to alluvial depositions, producing aquatic plants and brushwood commonly found in swamps and bogs, gradually acquired a soil composed of vegetable remains, commingled with sediment washed from off cultivated lands and the off-scourings of villages, until an accumulated super-soil has been formed from one to three feet in thickness. Art has now discovered and applied the draining tile to the complete drainage of such swamps, and resorted to irrigation as an effective means of decomposing a mass of vegetable earth, which contains a store of the elements of fertility, besides a deposition of rich alluvian is at the same time spread over the surface. Fruitful meadows have therefore arisen from beneath living waters, which bear along with them seeds of fertility; and fresh and blooming vales have appeared, where the swamp and the wilderness had previously disfigured a flowing landscape. Nature and art combined, twin sisters in the hands of man, in all the profusion of illimitable products and prodigality of organic being, have smiled upon his busy toils. The bounties of Providence have been disclosed to view, and vast means of subsistence yet in store, prepared for our use by omniscient intelligence, are now elicited in the most available forms; and a boundless outlay of profitable capital is ever open to our view.

Clustered around those fruitful vales, where a genial atmosphere is no longer chilled by frozen dews, ridges of diluvial depositions are laid side by side. For these an annual store of manure is provided in the adjoining vales. Here also the husbandman carries into effect the various arts of agriculture, in a proper clime, under favourable auspices, and with a ready supply of adventitious manure at hand. Such diluvial formations, however, though of one common origin, yet they often differ widely in natural fertility, according to contingencies in the time of deposition. In one place granulated clays resting on bases of gravel and sand are found. These have contributed to drain off stagnant waters, and promote the pulverization of the soil by the worm and the beetle, those unceasing agents of the cultivation of the earth, in preparing the elements of fertility abundantly. In other places, the same clays rest on solid and impervious bases, which check the activity of organic being, occasion every thing to assume a stagnant form, and preclude the calling forth of that energetic agency, which distinguish a state of sterility from that of fertility and fruitfulness. Here also, similar materials differently compounded together, have produced exceedingly variable results. Still a common and prevailing feature appears. In the diluvial ridges of the great Cumberland Plain, striking defects are observable in the composition of its subsoil, and its supersoil as well. The clay is excessively granular. Next, calcareous earth is deficient. To compensate for these obvious imperfections in one respect, a less tenacious soil is more readily tilled, and when a fine tilth has been acquired, it is less liable to run into arid masses than soils composed of finely divided clays and calcareous earths. Art is so far applied under highly available advantages.

Such land is well adapted for improvement by under-ground draining; it promises profitable returns for the investment of capital in its improvement; it is readily cultivated; weeds may be speedily eradicated; its returns are abundant for the labour bestowed; it retains the state of friability imparted by art, and the husbandman is therefore stimulated to contribute alike industry and art to its careful cultivation. The application of the plough and the harrow, a liberal investment of capital in its permanent fruitfulness, the subsoil plough of Mr. Smith, and Mr. Wilkes' wonderful brake harrow, all invite the best exertions and the most intelligent methods of the agriculturist. These prepare the way for the adoption of THE PRINCIPLE that weeds shall never be allowed to make any progress—that a skilful combination of processes shall ever keep them in check at a reduced and trivial expense; that profitable plants shall be nurtured, and unprofitable ones eradicated. The soil so prepared is fitted to reap the renovation of rest, and an augmentation of fertile properties. Philosophic reveries may assume the contrary; and tell us that the soil is liable to wear out. Granted. Nature may exhaust her multiplied powers. But a renewed fruitfulness is equally conspicuous, and the ready instrument of providential laws. The infinite wisdom of God, in carrying out the ends of creation, obviously retraces none of his leading steps, nor is ever negligent about the welfare of his creatures.

Even the lowly worm and busy beetle have accomplished prodigies in carrying out the objects and provisions of creation. Shall man then, aided by the plough, the harrow, the subsoil plough, and the searching brake, under the guidance of reason, the aids of science, the multiplying powers of capital, and the hand of the farmer, accomplish infinitely less than these lowly creatures in the hands of Providence? By no means. The predicate is untrue in fact, if not impious in conclusion. If nature be capable of exhausting her powers; she is still more capable of renovated vigour.

Agricultural science, we readily confess, as applied to the prevailing soils of the Cumberland Plain, is but slowly developing those vast stores of subsistence and individual wealth, which lie concealed in its geological arrangements; and are ready to start forth and return augmented superabundance, proportionally as agricultural science is more generally diffused. The seed is sown, it has budded, and fruitful crops give evidence of plenteous returns. Effective and extensive organization is a leading law of Heaven. Geology ever teaches us this obvious and immutable truth. The progressions of Infinite wisdom are unceasingly leading to higher perfections, and a more complete conquest over darkness and chaos. We have but to follow the providential means placed within our reach, to secure that public and individual happiness, which is prepared to our hands.

In ascending from a low level on the Cumberland Plain, bordering on diluvial beds, a narrow space of red freestone forms the next gradation, overlaid by diluvial clays on its northern border. Where the red freestone is sufficiently elevated, and the overlaying of clay thin, or composed of gravel or sand, a dry soil has permitted the worm and the beetle to carry on a long series of active culture, which has contributed to enrich the soil. No sooner is the red sandstone considerably overlaid by clay impervious to water, than the soil is less genial and fruitful, more difficult to cultivate, and less profitable to the farmer.

The native dryness of the red freestone soils is evidently a cause of their superior value. On them, plants of a more nutritive description have prospered and gone to decay than on wetter and less healthful land. Animal life, its active energies, and decay have also contributed to enrich the soil on which animated nature has toiled, lived, and died. The usual elevation of this tract, seldom exceeding 250 feet above the level of the sea, enjoys a salubrious atmosphere, neither chilled by fogs, nor in a region on which the rays of the sun impinge but faintly.

In this geological ascent, the coal measures form the next grade. Commonly overlaid by considerable depositions of arid clay, they are ungenial from a double cause. Their general elevation above the level of the sea may be taken at 300 feet; and their imperviousness to water renders them cold, arid, and profitless. Moreover, the tract of land in Cumberland, which is occupied by the coal measures, lies on a northern aspect, the invigorating influence of the sun is diminished, and the quality of the land thereby deteriorated in no inconsiderable degree. It is a leading feature in the value of this class of soils, that they more nearly partake of a common quality than any other series met with, owing to the general uniformity of the subsoil on which they rest.

The mountain limestone group claims our next attention. Commonly elevated above the summit level of diluvial deposits, barely within the range of finely-divided matter thrown uppermost; naturally dry from the fractures it contains, and composed of calcareous materials; a considerable depth of fruitful soil is commonly met with in the limestone range. Hence this class of soils may be pronounced the most favourable to vegetation, inasmuch as the materials of which they are composed form a cause of natural fertility. Yet their elevation above the level of the sea, mostly exceeding 400 feet—a climate so ungenial, on northern aspects more especially—deteriorate their value in no inconsiderable ratio. On southern aspects, however, the lower levels of the limestone range contain highly productive and valuable land, producing every species of culmiferous and gramineous crop in profuse abundance; and the vallies along which the waters of the limestone district flow, holding lime in solution, mark them out as peculiarly fruitful, and superior to waters coming off aluminous and silicious beds alone.

The next and highest grade of land in Cumberland is the transition or secondary formation. Among its vales, where mountain torrents have hurried from the hills, large quantities of detritus, or even on the bases of this class of rocks themselves, where observed to crop out on low levels, very superior soils are found, such as the vales of Bassenthwaite, Loweswater, Lorton, and Keswick, all lying within an elevation of 250 feet above the level of the sea. When we ascend 400 feet above that level, climate operates, soils diminish in fertility, and cultivation is then rapidly verging to a close. At 1000 feet above the level of the sea, profitable cultivation almost uniformly ceases; and pasturage is the prevailing form in which land on still higher levels than this are farmed.

In every grade of these soils we discover in how much physical laws have determined their original quality; and that their diversity in fruitfulness has originated in trivial differences under which depositions have happened to be made. Immediately to the westward of Carlisle, the Cumberland Plain is occupied by an extended field of firm clay, equal in texture, of considerable depth, and, of course, impervious to the ready absorption of water. It may be estimated at 10 miles in length by 6 miles in breadth, elevated upon its table summits about 200 feet above the level of the sea, and ascends on all sides from lower levels. As might be expected, the native quality of the soil on this field of clay is uncommonly uniform, and wanting in fertility, simply because the worm and the beetle have made little progress in its cultivation; deficient in calcareous earth, the clay too granular and rough in its texture, and a wet surface by nature prevails, which is adverse to the accumulation of fertilizing properties. Yet the same clay, had it rested on a dry base, might have been fruitful in its original quality. The plants which grow upon it being antiseptic in their tendencies, animal action on the soil is limited, and deficient in animal remains, it rests in a state of almost primeval barrenness. But does such a soil forbid a profitable outlay of capital, the application of industry and agricultural science? By no means. By the aid of the plough and the harrow, the subsoil plough, and Wilkie's brake-harrow, applied according to scientific processes, which decide that weeds shall make no progress, and be thoroughly eradicated from the soil at the least expense, preceded by complete under-ground draining, and sown down with the seeds of the finest grasses, its natural barrenness may be successfully overcome;—because the application of such a chain of processes would create a deep and aerated soil, infuse into its body the elements of vitality, prepare the way for the roots and tendrils of succulent vegetables striking deeply and freely into the earth, and thereby repairing, by industry and art, that which nature has originally omitted, yet not denied the gain thereof.

So viewed, the soils of Cumberland are analogous in their origin, but differ in the geological incidents that have determined the manner by which they have been assorted in their deposition. Their native fertility, from this cause, varies materially. Moreover, what is here said of Cumberland, applies to the entire north-west section of England and Wales, up to the great coal line. These soils are commonly tilled at a light expense; they consequently repay cultivation with profit; and the longer and better they are so treated, the more productive they grow. Improvident and unprofitable cropping are certainly prone to wear out the powers of the soil. That is by no means the rule which prevails in the practical agriculture of our day, but the exception to the rule, and decidedly at enmity with profitable farming, and the profitable investment of capital.

The vale of Keswick here claims some Geological notice in reference to its soil. The level of Keswick is said to be 240 feet above that of the sea. Yet that part of the valley of the Derwent in which Keswick stands, lying within the limits of the mountain district, and though in some measure open eastwards as well as westwards, contains neither lime, coal, nor red freestone, and neither much clay nor sand. Why is it so ? We answer, because the tidal wave originally abutting upon the northern escarpment of the Skiddaw cluster of mountains, turned drift in the same direction; and also because the level of the vale eastwards exceeds the limits of the limestone depositions. In a Geological light, this fact is very interesting, since it coincides so fully with Neptunian laws. It goes to prove, that had volcanic force elevated the secondary series, subsequent to the date when tertiary deposits had been made, the vale of Keswick could not have failed to contain a portion of those depositions. But no. They are not found there, except diverging a little into the gut of the river Derwent to the westwards of Cockermouth. Because, at the date of the tertiary formation, the prevailing channel of the great waters had ceased to carry depositions along the vale of Keswick. All the vales that lie without the walled circuit of clay slate, and on a similar level, are completely overlaid by tertiary formation. Within the field of clay slate they are not found. No sooner do we observe the mountain defiles of the west open both westwards and eastwards, than the tertiary formation commences and continues on a higher level than the clay slate formation in the vale of Keswick; and this rule uniformly applies to the mountain vales of Cumberland; lying on the western side of a more early and elevated formation, the drift of the tertiary series is not found within their limits; exhibiting every trace and evidence of deposition by a current flowing from the eastwards. Had a westward current then flowed through the vale of Keswick and some others, the tertiary formation, must have been found resting on the secondary one. In the western vales of Northumberland, Durham, and Yorkshire, which are freely open eastwards, this is uniformly the case. Hence, in the vales of Keswick, Lorton, and Loweswater we find a class of purely transition soils on a low level, and are able to appreciate the fruitful qualities of this class of soils, when resting on porous foundations, covered by finely divided detritus brought down by mountain torrents. Moreover, when the finely divided materials of which the secondary formation was originally compounded, were re-decomposed by the action of torrents, we plainly witness the constituent elements of this class of rocks; and are satisfied that igneous fusion has had no concern in their primary deposition.

The soils of the north-west section of England within the coal line, bear an indistinct analogy; however, to the south-west section thereof, which lies beyond the coal line. Belonging to a subsequent formation altogether, they are compounded of materials different in their proportions and qualities. Clay, sand, and calcareous earth form the basis in both instances. At the same time two incidents constitute the variation. Calcareous earth abounds much more in the subsoil and supersoil of the south-east, than in those of the north-west; and the three main earths, clay, sand, and lime, are much more finely divided. Notwithstanding these differences, there are peculiarities in which they agree. The same sort of materials, in both cases, produce better or worse land accordingly as they happen to lie on a dry or a wet subsoil. Diluvial and alluvial causes have also decided the mode of deposition.

The Fens of Lincolnshire, Northamptonshire, and Cambridgeshire are formed of marine and fluviatile alluvian blended together, the same as the marshes of Cumberland are. Coming from off materials which have been more finely divided, and containing a large proportion of calcareous earth, also in a more finely divided state, their native fertility exceeds those of Cumberland.

For like reasons the vallies of the north-west section are inferior in fruitfulness to such as the Welland, the Nene and the Ouse, lying within the south-east section of the kingdom.

Ascending to the diluvial beds of the south-east, when deposited in deep and extended masses, their fine division renders them more impervious to water, and much more expensive to cultivate, than the more friable and granular clays of the north-west. Both may be classed among arid and inferior soils. Though the one may be more cheaply tilled than the other, yet the balance of annual value is in favour of the south-east section of the kingdom, as its finer division added to the presence of lime more than compensates additional expense in cultivation. In the north-west section a deposition of highly granular clay, intermixed with layers of sand, and resting upon a porous foundation as much as thirty feet from the surface, may be nevertheless dry, and of superior annual value. Again, an intermediate class of soils prevails, which may be said to be of a medium quality, capable of being effectually and cheaply under-ground drained, and raised to the value of what may be called superior soils.

In this respect the north-west has a considerable advantage over the south-east section. In the latter not more than six feet of impervious clay, overlying an oolitic or chalky base, may reduce such land to an inferior or medium soil, without the same facilities of under-ground draining; besides the expensiveness of the various processes of cultivation, when in a state of aration. This is so far a material defect in the soils of the south-east, and arises from a trivial difference in their original composition.

Those soils in the south-east, which have a considerable depth of super-soil, resting immediately upon oolite or chalk, are much more expensive in tillage than the red freestone soils of the north-west. But they excel in fertility and productiveness; whilst the abundance of finely divided clay and lime they contain, and the defectiveness of those valuable ingredients in the other, render them superior in value, and more productive in almost every sort of culmiferous crop—yet inferior and precarious in the cultivation of green crops, for which the north-west is famous; in drilled turnips on once about ridges especially, which fail on the other, and is a material drawback.

In the cultivation of brush-wheat, or wheat from clover lays, the dry and calcareous soils stand pre-eminent. Indeed, this sort of crop cannot be recommended on any other description of land. Why is very obvious. A good wheat soil must be dry; it must contain a considerable portion of finely divided clay, a considerable portion of finely divided lime also, and must possess a good depth of soil. Of course those soils possess these requisites, and are the only class on which brush-wheat may be successfully obtained, or soils composed of similar constituent elements. Within the limits of the coal line, this class of soils is rarely found, since lime was not a usual accompaniment in the deposition of diluvial beds; and a non-observance of a defect and a difference so striking has led to disappointment and loss in attempts to gain wheat from clover lays. The friable soils of the north-west are, however, adapted to obtaining wheat from bastard fallows in great perfection, by a chain of processes to which Wilkie's brake applies. This is a new practice which has been crowned by pre-eminent success. Certainly, manure is applied; whilst brush-wheat is obtained without it.

Distinguishable from superior wheat, barley, and clover soils, which are dry enough, and wet seasons rarely injure, but often augment the crop considerably, a description of barley, turnip, and clover soils are formed in the south-east in which sand and finely divided lime prevail in place of clay and lime. This sort of land is rarely found in the north-west of England, as the best calcareous soils are commonly divested of those excesses in composition which generally belong to the south-east. On the north-west the finest crops of wheat, barley, turnips, and clover are obtainable, but not brush-wheat. Some more suitable preparation is required, or one which imparts more firmness to the soil.

From the deep calcareous soil of the south-east, we ascend to the higher elevations of chalk. Here a want of soil is observable, and the same incident often occurs on the lower levels of this series. The north-west scarcely affords a parallel to this class. Of course these soils maintain an inferior value, and are apt to burn in dry seasons, and when rugged and thin of soil are fitted only for the pasturage of sheep. These are the highest levels found in the south-east division of England.

Along much of the great coal line, a class of soils different from the two extremes might be expected, partaking of the qualities of both in part, and lying in the midland counties chiefly. Leicestershire, Staffordshire, Warwickshire, and Worcestershire, are the counties which afford the most strict examples. In a Geological light this fact is interesting, especially as Bardon Hill is a pivot by which those depositions have been determined. For general purposes it is here that the best class of land is found. Resting chiefly on a dry foundation, pervious to the absorption of excessive wetness, finely divided clay and lime are found more divested of excesses and defects, than belong to the two extremes of this line. The river Soar, Avon's silver stream, and the source of the river Trent, mark the central ground here alluded to. Diversity of soil certainly prevails everywhere. Still the general presence of finely divided clay and lime, without being in excess, and resting upon an absorbent sub-soil, or dry foundation, impart to us the leading features of this portion of England.

General and hasty as the glance here taken at the connection existing between Geology and the quality of land may be; yet it sheds considerable light upon both subjects, and prepares the way for the reception of sound agricultural science. It is here we learn the origin of each class of soils, and experience and observation point out their exact applicabilities and adaptation to such plants as may be profitably cultivated. A like train of acquiring sound knowledge leads us to watch the progress of natural evidences, until we are able to till and cultivate the soil on the cheapest, most effective, and successful modes. A rule which applies to the sands of Norfolk may be ill adapted to the fens of Lincolnshire and Cambridgeshire. Again, there is scarcely any analogy between the treatment of the best oolitic soils of Northamptonshire and the most fertile loams of Cumberland. Not only are a different set of modifications required in detail, but the general routine of cropping and farming scarcely assimilate at all. The leading rules of agriculture, as a science, may, nevertheless, hold good. We seek to destroy weeds. The various modes and forms in which they generate and insinuate themselves into the soil must be narrowly watched, their progress arrested accordingly, and finally eradicated from our fields. For they are not indigenous to the soil because they appear to grow spontaneously, but because they have gained access to it, and kept possession. They must, therefore, be dispossessed of their hold again, by discovering an effective mode of doing so in a profitable manner. Watching the season and applying the mode of attack according to the several habits and forms in which they spread themselves. On the contrary, those plants intended to prosper either temporarily or permanently, must be put in possession of the soil from which noxious weeds have been rooted and dispossessed. For opposite reasons, therefore, we must apply those incidents which contribute to productiveness.

But the same plant is by no means suited to all circumstances and soils, nor is the same rotation of crops, nor the same rules and modes of tillage. On the north-west of the coal line, a soil resting on a granular clay, effectually drained, and containing a considerable portion of vegetable earth, with finely divided clay deficient, and calcareous earth wanting, when once reduced to a fine tilth, it remains so for a season. A strong and dry calcareous soil so treated on the south-east of the coal line, would run into a body again the first heavy rain that happened. Nor is the same order of cropping applicable, nor the seasons of sowing, nor the same system of stocking a farm, nor the application of the same animal power to its effective tillage. On discovering those differences, and the causes of such differences, we prepare the way for rendering agriculture a science, resting upon geological data. Taught the origin of those differences observed in the value of land, we are prepared for commencing a classification of soils, and their applicability, coincidently with their actual properties. Mere names, the signs of abstractions, may prove delusive signs of knowledge, and check the current of investigation. Because a soil is called a loam, or a strong clay, or sandy, it does not follow that these terms convey a correct idea of their quality, though climate were the same, as the constituent materials of which they are compounded may be essentially different. Being similar in texture and ordinary appearance, are not the only indexes of equality in value and fruitfulness. Geology carries us almost at once to the differences in the quality of soils, and, combined with chemical analysis, clears the way for a beginning of correct classification. Sands are composed of stated materials in combination. Loams and clays may be treated in a similar manner. In these arrangements, the absence or presence of lime forms a leading feature, and the formation and accumulation of vegetable and animal remains are consequences. Incidents follow. Wetness and dryness depend merely upon that porosity or imperviousness in the subsoil which the casualties of deposition have fixed. Climate also has its given peculiarities. The practical means of repairing natural defects in any given soil, then assume a plain influential form, and we proceed orderly to work, under all the advantages of skill, experience, and observation.

Agricultural science, as a plain and intelligible art, has therefore to begin almost anew, divested of inapplicable generalizations, which convey no exactness of ideas, and of rotations of cropping, that comprise the details of agriculture rather than its leading principles. Viewed on such terms, agriculture must be traced from its first premises to its practical details, according to the various peculiarities under which it may happen to be placed. Then it becomes the proper history of nature and facts, adorned by providential laws. Every trace of its outline, and all the minute contingencies of its details, assume the most certain and intelligible forms, the strictest plainness, and the most delightful watchings of nature's processes—of Heaven's organic harmony and symmetrical beauty, divested of idle and delusive metaphysics, which assert a tangible substance, and present airy shadows, like the unravelling of physics by a mist of equations, in place of unsophisticated knowledge. Delighted and instructed by a plain unfolding of modes and events, deduced from first principles, the mind speedily arrives at practical details, which awaken our interest, and engage the most pleasing sympathies of the human heart. The chains of error and barbarism drop off with almost magical celerity, and the embodied fancy, in watching the habits of plants, and the modes of either nurturing or destroying them, readily strides the realms of organic harmony through nature's paths.

Intricacy vanishes. The sequence of physical laws are spread before us in obvious and comprehensive classes. Order and form cast their lights on the labyrinths of nature, and her complications are no longer entangled in abstruse mysteries, but lie on the surface of events. Nobody reads agricultural works. Because they are either composed of unmeaning generalizations, or common-place details indifferently described. Let agriculture become natural history, and while it instructed the student, it would amuse his faculties of intelligence, by faithful descriptions of the various modes in which organic being is carried on. Take the eradication of the common thistle. It sheds its winged seed, and is rapidly spread abroad far and wide. Its roots extend themselves beneath the surface, especially while land is in a state of tillage, and cast up plant after plant as they run along. Wilkie's brake in fallows draws forth the roots of the thistle by the application of its tines; and no sooner have its tender buds appeared above ground, than the shears of that scythe-like implement grub up many acres in a day; and the annoying weed is either effectually checked or destroyed in every form of its generative means. Coltsfoot is even more rapid in spreading itself on land in a state of fallow, than the common thistle, and by precisely similar modes. Like means, therefore, destroy coltsfoot as speedily and effectually as the common thistle. Here a great principle announces itself. To destroy weeds they must ever be checked in their progress, when they will naturally grow themselves out, and die. But even this principle requires in its application a varying modification. The large Scotch thistle is prone to grow by seed, subsequent to the best cultivation. It is also an annual, and should never be allowed to seed among either hay, grass, or on pasture. A right chain of processes is therefore the foundation of purely scientific agriculture, in which time and a sequence of operations prepare land much better at one half the expense. Reducing field culture to garden forms, cleanliness, and fertility.

Geology so far instructs us in the rudiments of agriculture. Finely divided lime is a valuable ingredient in the composition of a soil. In the coal measures and up to magnesian limestone it is commonly wanting. When vast testaceous remains underwent decomposition, and were deposited on the surface of the fourth formation, it was the same as if powdered bones had become a component part of the soil, and fitted it for the production of brush wheat; whilst it could not be profitably raised on the newer groups of the tertiary formation, because the powdered bones were omitted. Such are the sort of facts which are capable of moulding agriculture into a regular science. As a literary topic it would then become amusing and instructive at the same time, unexampled in the beauty of its facts, and the force of its inferences. Alike delightful to the general reader and the philosopher. Training the mind in the arts of induction, leading it spontaneously into all the breadth of generalization, and all the minutiæ of particularization, or the useful application of science and skill.

British agriculture, viewed through the medium of plain and enlightened science, would seem but in its dawn, rising to a state of vigorous maturity, active industry carried on in better forms, and a liberal advancement of capital in the careful cultivation of more fruitful fields. The soil of our sea-girt Isle is by no means wearing out, as closet philosophers would infer, but under the direction of liberal landlords, and in the hands of skilful tenants, its annual fruitfulness is multiplied and multiplying.

CHAPTER VIII.

ON THE APPLICATION OF GEOLOGY TO THE PHYSICAL LAWS WHICH REGULATE THE UNIVERSE.

When Sir Isaac Newton demonstrated that the laws of the universe were regulated on fixed and mathematical rules, the movements of which were regular and constant, he brought us nearer to an acquaintance with Heaven's laws, by shewing us their unquestionable existence. Bold as this generalization appears, it nevertheless totally fails in bringing investigation into definite forms. That matter was organized on general principles, was all that the discoveries of Newton made known. What those principles were, still lay in the realms of darkness profound. Something was placed under regulated movements. There knowledge stopped, and philosophy took its stand. Any leading peculiarities in organic matter were as entangled in mystery as ever, and not even thought about. Though they were obviously the main subject to be thought of. By the application of Infinite wisdom, and power omnipotent, the matter of the universe is balanced and brought under organic actión. What are the differences observable in that matter, is a question on the surface, and inferentially unavoidable. Yet has never been once asked, even though it be the subject matter of all sound philosophy.

Dr. Dalton has had the high honour of breaking through the seemingly spell-bound chain of being, by shewing that matter is composed of atoms which differ in volume. The inference is here plain. Then the uniformity of physical forces apply to materials compounded of atoms that differ in form, divisibility, and density. Diversity in matter arose; and that diversity has been poised and brought under organic action, as demonstrated by Sir Isaac Newton. Being is not in a state of chaos. Regulated action on strictly physical laws prevail. An unanswerable truism about which no doubts can be started.

Sir Isaac Newton announced a bold generalization. Dr. Dalton's discovery was no less comprehensive in detail. The one disclosed the existence of a general law; the other a leading feature in the materials to which that law applied. Neither of those truly great men, most wisely, assigned any cause, why either matter or intelligence exist at all. They do exist. The laws and form of that existence, have determined the limits of human investigation. Dalton may be said indeed to have discovered a cause on which the laws demonstrated by Newton essentially depend. Had the properties of matter been perfectly equal in form, divisibility, and density, the superstructure of organic action must have been without a foundation to rest upon. Omniscience created a foundation, therefore, and based it upon the differences which the atomic structure exhibits. Perfectly suitable materials were moulded and formed into all the order and harmony of the universe.

Dr. Dalton having discovered a feature in atoms, stopped there. He, therefore, threw no mysterious veil over the philosophy of a future day. Not so are we to estimate Sir Isaac Newton, or those who have attempted to start where he left off. Having discovered a law, a verbal cause of that law was assumed in place of identical properties and features in matter. When he saw an apple fall to the earth, he inferred that the attraction of gravitation brought it down:—On what principles? Verbal legerdemain! An attractive law was assumed, instead of more rationally concluding that it was forced down by the active agency of some opposing force. A verbal and delusive form by such means crept into Philosophy, and contributed to vitiate its pure rules; and which is aptly illustrated by the magical term of magnetic attraction, instead of magnetic force.

Those verbal delusions have proved unfortunate. Combustion must be attended by the matter of caloric, instead of combustion exhibiting an elastic property in all that reigns over and around us. Omnipotence and omniscience have accomplished nothing by magical operations. All depends on organic and physical laws. Atoms more and less readily put into a state of activity, present a tangible form to our ideas. The substitution of verbal signs, therefore, as the evidences of unknown laws, may prove a real hindrance to the reception of the plainest truths. To the everlasting honour of Dr. Dalton, he has made no endeavours to edge in his discovery by verbal assumptions. It is a fact, that the volume of atoms are different in the properties of divisibility. When laws and principles are unknown, and yet give out evidences of existence, it is unphilosophic to label them, with the signs of known conceptions. We witness the force of gravitation. Are we to conclude at the same time that the laws of attraction are different from the principles of physical force? Or, does the attraction of gravitation simply imply physical force, and nothing more? Such questions place the term in a delusive light. We say that matter and mind are. There the limits of our knowledge stop; and we make no attempt through the medium of terms to say why they are.

As atoms differ in one essential feature, may they not, and do they not differ also in form, surface, and density? Granting thus much, and which seem self-evident distinctions, a difference in volume and divisibility necessarily follow in the train of consequences. Crystals exhibit this property in solids. Dr. Dalton's discovery allows us to apply the inference to fluids as well. Philosophy here requires a distinct starting place evinced by geological phenomena; and even chemistry gains a new handle to work by. An aggregate of atoms spherical in form, infinitely divisible, polished in surface, and each maintaining material existence in itself, might in a state of immense activity, divide and subdivide until they were capable of occupying an immense space. Admitting this view of the divisibility and activity of atoms to stand hypothetically, the inference thereby illustrated is by no means questionable on that account. The form, surface, and density of atoms, may not be the less connected with the properties of divisibility, activity, and tendency to decomposition and recomposition. Active and inert forces may constitute the differences. Though we by no means discover the exact truths of physical forces by this hypothesis, we nevertheless ascertain the direction in which truth lies. The amazing elasticity of gunpowder is obvious. What becomes of its atoms on explosion? We may conclude that they lie scattered about in numberless fragments. Let this be so. The illustration still holds good. The elastic properties of atoms arising out of form, surface, and density, may not be the less correct. All we are able to learn of matter confirms rather than denies the inference.

If atoms be thus capable of and fitted for activity, should they acquire mobility, and come in contact with atoms equally active, yet by no means agreeing in form, surface, and density, they would naturally augment the force and activity of each other. The most sluggish atoms would consequently be driven into masses, or aggregates, which resisted the common war of elements, and sought a state of repose by the influence of their density opposed to the forces of fluidity. According to this view of an organic universe, there appears no necessity which we are able to conceive for any sort of original materials but one. The active agency to which Infinite wisdom subjected those materials, might speedily change the primary form, surface, and density of atoms, so that while some were unfitted for activity by amalgamation, others gained additional activity by a state of higher divisibility, originating in contact and attrition. In other words, some atoms might be beaten into aggregates, or masses, while others underwent and were beaten into higher divisibility, or fragments. Not that we infer that atoms were all equal as matter at the beginning of the universe, or which had no beginning, but that atoms are liable to change their properties incidentally and by transmutation, just as the clay slate of the secondary formation is in a great measure the same sort of material as brick dust, or the more active dust of our public highways. Grant that all atoms are capable of a high state of divisibility, yet, admitting that some are laminated, others spiral, spherical, cubed, angular, or rhomboidal: others indefinitely fractured, unequal in surface, and light in composition, it is obvious that those in a state of great activity, must be driven into separate sorts according to their several affinities and properties. Not only would this general assorting of matter happen, but classes of active atoms might take refuge as it were in all the crevices which sluggish and misshapen atoms might take, and so form a cement to whole masses.

It may be asked, are these arguments assumed as truisms? Nothing of the sort. The direction in which truth lies, is the consideration assumed agreeable to the laws of physical forces. It is also shown how easy it is for Infinite wisdom to organize and control materials so various and plastic. Nor are millions on millions of years required to bring the earth to its present state of perfection, as some philosophers have suggested, while still higher perfections are hastening onwards at an accelerated pace. Agriculture is yet an infant·art; and the earth comparatively barren in reference to its capabilities of fruitfulness. Capital, arts, and science; civilization, commerce, and international communion; the science of free and beneficial government, the spread of just laws, and a right estimation of industrial happiness, are daily moving onwards. God has not made the earth in vain;—and his purposes are obviously wise and just.

The doctrines to which the atomic theory lead, are unquestionably sound in their first premises. In expounding the laws of gravitation, Sir Isaac Newton fixed the exactness of organic being as applied to the universe. Atoms are the materials on which gravitation operates. Nor is it less plain that atoms in a state of powerful fluidity, may drive sluggish atoms into masses, and steady them in their balanced orbits, like unto our earth and all that inhabit this terrestrial abode.

The laws of gravitation prevail: that is undeniable. The matter to which that gravitation applies, it must be admitted, conforms to a general law. The great deeps move not, nor have moved, nor does the planetary system remain truly poised within its sphere, except in strict conformity to physical laws, even in the most minute details. Does not the power of steam, and the regulated action of the steam engine, afford full evidence of the correctness even of physical details? Certainly they do. To proceed one step further—shall we deny the steadied action of electric force? By no means. We may not comprehend the basis on which it operates, yet we cannot deny the regulated movements under which it has been placed by an all-wise Providence.

To descend to more plain and obvious evidences, which are nevertheless the results of more comprehensive and general laws. Why do we observe dry land repulse the sea, and the sea on the other hand repulse the land? Because the form, surface, and activity of the latter, stand opposed to the sluggish character of the former. Conformity to the obvious rule, that fluid action may impart more force to a comparatively light body than a dense body in a state of rest, satisfactorily accounts for such an occurrence. The force which a gun bullet acquires from the ignition of a few grains of gunpowder, needs no further illustration of the law here brought under review. We know gunpowder is a compound, and mainly owes its sudden and powerful elasticity to that compound. With the discoveries of Newton and Dalton before us, so plain and yet so conclusive as general truths, we can neither question the constancy of nature's laws in detail, nor doubt why those laws are so remarkably exact. Brought into operation by Infinite Wisdom, all works in order and harmony.

Laws so comprehensive and general, exhibit incidents which are common to matter, placed under organic forms devised by Omniscience. It is here we reap the elements of Geology. There is nothing at work in this branch of our subject which partakes of magical influence or delusive operations and terms. Matter is not drawn to the earth by attraction; but it is forced to the earth because a highly resisting body repulses the active atoms which occupy the regions of open space: so that sluggish atoms are driven into spaces of comparative repose. To take an apt illustration:—the travelling beach of the Low Holm has by no means been attracted into its present position and form, but driven there by tidal action, deposited in a comparatively water-logged space, and left there, merely because no adequate power for its removal existed. In a similar manner, a portion of the tide-wave of the north Irish Channel, dividing itself, and running in the direction of the Solway Frith and Morecambe Bay, occasioned a space of still water on Saint Bees Head, which led to the original formation of that prominent headland; and as violent south-west gales occasionally prevail, the ordinary locality of this water-shed is temporarily shifted, Whitehaven Bay is then scoured out, and deep water preserved.

On similar principles of tidal action, though on a mighty scale, we observe operations of the gulf stream in the Atlantic Ocean ever preserving its ceaseless revolutions. The original seat of that stream is to be found in the westward current of the great Southern Ocean, taking its onward and eternal course between the 55th and 70th degree of south latitude. Driven on the Cape of Good Hope finally, it is propelled through the gates of the Atlantic, and is naturally driven in a north-west direction. A parallel tide-wave, driven outwards by Cape Horn, is thereby projected in a south-west direction. Hence the water-shed of these north-west and south-west currents is fixed upon the headland of Cape de Saint Roque; and we question whether granite is found in that part of South America or not. It is not essentially required for the defence of depositions. The plain of the valley of the Amazon, that of the Mississippi, and the north-east of Europe, were consequently formed out of deposits driven into those extended spaces, not attracted in the ordinary sense of the word.

The elements of Geology are therefore deducible from the laws of gravitation unfolded by Sir Isaac Newton, and the atomic theory, as made known by Dr. Dalton. Thus much admitted, the rest must be established by inferential evidence, as demonstrated by the law of the one and the cause of the other. Indeed, these discoveries lead to an unavoidable train of conclusions. According to the universal law of Newton, exercised upon atoms—No, PARTICLES OF MATTER, some of which are spherical, laminated, cubical, and spiral, exceedingly different also in properties of divisibility and density—it becomes the business of philosophy to ascertain the results thereof.

Though we began our researches by tracing the ordinary laws of fluid action upon more dense particles or atoms of matter, yet they lead to the laws of universal gravitation, and that amazing diversity of particles which form, divisibility, amalgamation, and temperament, have produced in all matter. Here the materials acted upon by each other lie before us, and we have also learnt that that action strictly conforms to physical laws. Newton applied those laws to the universe, and demonstrated the certainty of a leading truth. Indeed, that certainty, in the return of day and night, in the periodical courses of seasons, in the fixed revolutions of the planetary system and of tidal phenomena, was, previously to the day of Newton, written on the surface of all events. Regulated and organic action, as framed by Infinite Wisdom, were broadly announced by all that could be observed above, beneath, and around us. In applying the same obvious laws to Geology, we trust that we have raised up another accepted witness in favour of that mighty cause, which eternal truth proclaims.

A diversity of particles in matter, added to their transmutable properties, fits them for modification and applicability to organic forms, whether in the hands of eternal Providence, or more lowly beings like ourselves. The field of investigation here thrown open, the watching and tracing of Nature's laws, sincerely and humbly in our hearts endeavouring to adorn truth, is boundless as the universe; and adapted to the most orderly, unremitting, and profound research. In the solar system, where force and unerring activity are so wonderfully exercised, the sun would appear to be the prime mover of a machine stupendously sublime. The annealing, hammering, rolling and compounding of atoms, particles, and masses here carried on, at the same time ever resolving them into simple elements again, cannot be for a moment doubted. Designed in the spirit of intelligence, and working with wondrous harmony and certainty, Omniscience is undeniable.

May we not here claim the indulgence of illustrating some of the features of sublimation so boundless. If iron, for instance, be composed of an amalgam of laminated and ductile particles, which have undergone a process of fusion, hammering, and tempering, it cannot be doubted that any peculiar heat, force, and temperament employed would affect the properties of the iron produced. Experience would say unquestionably. The same train of experience would lead to an inference that alluvial clays, diluvial beds of clay, the indurated clay of the coal measures, the clay slate of the secondary formation, and the clay of which granite is partly compounded, differing somewhat in granulation, or variety in the particles employed in the work of fabrication and admixture, might readily produce the distinctive properties displayed in each, without at all requiring the hand of time, or the indurating properties of heat or fusion. In the preparation of lime mortar, and the making of bricks, every body knows how much their peculiar quality depends on tempering, the preparative means they have undergone, and the proportions and qualities of the material employed.

With such evidences before us, we would not hastily admit the necessity of a lengthened process in the production of clay slate ; nor doubt that products exceedingly dissimilar in hardness, yet formed of the same component materials differently treated, might be fabricated in a short period of time. Even though the materials employed were the same before they were assorted, amalgamated, and subjected to a variety of processes. Instances of this sort might be adduced to infinity, all tending to show how speedily the hand divine may have fitted up our earth for the abode of animated nature, and for man, the last and final work of Supreme intelligence.

Suppose that a designer had had no hand in the construction of the earth, and that an endless sequence of Geological events and processes were allowed, no lapse of time could have ever subdued unmitigated chaos. Some unfortunate incident must have destroyed every trace of order and harmony in combinations again and again; and chaos predominated through millions upon millions of ages. On the contrary, an omnipotent and omniscient God admitted, the most varied and plastic materials to work upon, and the highest instruments of power at command, with infinite wisdom besides, a comparatively short period of time may have sufficed for the creation of our earth. Let the materials required be driven out of chaotic space into a mass; let them undergo chemical action ; let the granite formation be indurated in the bosom of the earth; let it be uplifted; and let those depositions be completed of which the rest of the dry land of the earth is composed, any considerable extent of time need not be begged.

Do the laws of gravitation imply the action of atoms on atoms, or of particles of matter on each other, and something more? Certainly. Divine intelligence has balanced and steadied the universe. Yet we need accept no ideal law of attraction in addition to gravitation. The physical force of particles of matter on each other, or of atoms infinitely divisible driving infinite series of inert bodies into vast and compact masses, which repulse active agents by the force of their density, is quite enough. The admission, nevertheless, leads to some critical uncertainty. If it be a property of dense masses to repel more active matter, does the moon by arresting active force on the side of the earth she stands upon, withhold pressure by arresting the course of that action, or is pressure multiplied by repulsive laws? In either case the phenomena of tides may be the same. Still an attractive law, distinct from the force of gravitation, is uncalled for. If repulsion be equal to the square of any given dense surface, the laws of gravitation assume a form tangible to thought, and the attraction of gravitation is needless. Active atoms are certainly adequate to drive inert ones into masses; and inert atoms in dense masses are evidently equal to the repulse of active atoms in a state of excessive fluidity. Sir Isaac Newton has shown that the laws of repulsion are mathematically exact, and according to the extent of surface. Indeed, constancy in the periodical movements of the heavenly bodies themselves had previously demonstrated the certainty of general laws in the system of the universe; and that tidal action obeyed the same original impulse.

It is obvious that the higher the flow of tide in isolated seas, such as the North Sea, the Irish Sea, the British Channel, Saint George's Channel, and the Bristol Channel, the greater the abstraction of water from somewhere else, as those seas contain no tide within themselves. The origin of the tide-wave is to be found in the deep pulsations of the Atlantic Ocean. Whether the moon checks atomic action on the face of those mighty waters, or augments its force, the phenomenon would be precisely the same. Can the Atlantic suddenly gain more water from the Pacific Ocean? Does the tidal elevation in the Irish Sea augment the volume of the Atlantic? Certainly not. Then what is gained in these isolated seas is subtracted from the Atlantic; and the phenomenon is the same whether the planetary impulse be checked or multiplied. But here we observe nothing to warrant attraction distinct from the mere force of fluid action, and the counteraction of inert repulse. Whilst the laws of gravitation, as mathematically demonstrated by Sir Isaac Newton, stand unassailed, and must be accepted as unassailable in truth, his verbal invention of the attraction of gravitation vanishes like some idle vision of the brain, and gives place to sounder and more substantial laws.

In the unfolding of plain and comprehensive facts, Newton and Dalton are placed upon an immutable platform. With the most profound respect for the reputation of Newton, he appears to fail in theory. Active atoms repulsed by the earth might force an apple to the earth and keep it there. Yet inert particles seem unfitted to draw it down. But they would not repulse its gravity like the atoms of volatile matter. The travelling beach of the Low Holm has been driven to its present position by a flow of the tides, and by no means drawn there by tidal attraction. Our objection is not to a fact, but to a verbal delusion, veiled in a mist of equations and assumed attraction. We readily grant the influence of centripetal force; yet centrifugal force would obviously predominate if a repulsive force did not edge it around. On what does final repulsion rest? On infinite organic action pervading infinite space. Then we grant the finite principle to be inconceivable to the human understanding.

Why should not atmospheric weight be called attraction? It is called pressure. An agent which gives force to the locomotive steam engine may be surely equal to the forcing of an apple to the earth. Yes! equal to the pressure of the globe upon its centre. Powerful as this immediate and and manageable agent is, yet we know that another and higher force exists still more active and irresistible—electricity. A force which insinuates itself into the atmosphere, illuminates the heavens themselves in its path, and causes the earth to tremble perceptibly beneath its thunder. If we appeal thus to extraneous force, it manifests itself abundantly in the active atoms which unceasingly flow above and around our terrestrial abode. We need, therefore, ask for no magician's influence. Unknown agency need not be supplied by verbal visions infinitely more delusive and evanescent than electric powers. Let attraction signify an unknown force, then its meaning is intelligible.

Nor do we want means of cohesion. Pressure is admitted; so is inconceivably subtle and active atoms from water to electricity. These are ever ready to insinuate themselves into the smallest vacant spaces. With these infinite forces continually at work like so many hammer-men, continually laminating and compounding atoms into masses, means of cohesion present nothing unaccountable, though we be unacquainted with the modes and processes by which physical agency operates. When we get rid of such mysterious terms as attraction and cohesion, then we shall begin to consider the practical forms which cause matter to adhere to matter. We have pressure, particles of matter in all forms, and of every volume. So far the means of watching the processes of cohesion are not wanting. Little inlets lead to the nature of mysteries, until demonstration follows, and we open the subtle web of being by carefully unfolding what lies nearest to us first, as the path which leads to more distant and complex operations. The puddling of clay is the plainest of all processes, yet we witness how speedily by shuffling particles nearer to each other a low state of cohesion is effected. In the working of iron also, particle is beaten into particle, until it becomes a more ductile mass.

With a forge so vast and effective as the universe, a laboratory so stored with ingredients, and mechanical organization the most comprehensive and complete, can we doubt that an infinite variety of products may be fabricated from a few simple materials. The works of the Deity, it is very true, are too comprehensive and full of wisdom for our conceptions to grapple with satisfactorily; yet that is a most futile reason for denying the interference of Supreme intelligence. It is most strange, indeed, that while every step we take in knowledge evinces more extensive organization and design, yet light so sure seems ever mingled with higher doubts. At the same time, while we shed our lamentations over perversions so obtuse, it is pleasing to observe truth prevail in the end, and lost reason return to sober sense again. The speed with which the universal machine performs its mighty functions, the correctness with which its processes are carried on, and the harmonious simplicity of its details cannot be doubted, even though the causes thereof lie far beyond our means of conception. Newton has certainly demonstrated that the universe is regulated by a train of uniform laws; and Dr. Dalton has shown that materials are provided as appropriate as are their various uses and purposes. Crystallization had previously proved that the form and volume of particles of matter differ. Hence arise a sequence of inert and active forces, the flux and reflux of which occupy space, brought under the control of balanced laws, and steadied in all their movements.

Force is the only law admitted. Organic force has always originated in knowledge and power. Such force is therefore poised by intelligence. So viewed, philosophy lies in a small compass; and one of the main considerations appears to be, what are the properties and forms of the materials out of which force is fabricated? That their form is varied, and their properties fitted to work out every purpose of inert force, universal harmony, and vitality cannot be questioned. Nor are the views here taken formed without a strict regard to facts and known results. Geology points out the true path to generalization; and Geology itself is explained on the common laws of the universe. As physical force has collected together and deposited plains so extensive as the valley of the Ganges, that of the Amazon, the Mississippi, and the wide spread levels of Eastern Europe, by operations of fluid action, we need not question the means of power, and may safely admit its infinitude. But how in Geology did that power work? By repulsive as well as by fluent forces. Mighty granitic breakwaters repelled the flux of the ocean, and converted it into an instrument of power, by which the dry land of the earth has been mainly fabricated. Even more. Whilst mountain torrents were ravaging the dry land, refilling the great deeps, and invading the shores of the ocean, tidal action returns all this detritus on land again, thereby securing and extending the fertility of the habitable globe. May we not apply those laws universally?

Suppose that the presence of the moon occasions an increased pressure of elemental action on the waters of the Atlantic Ocean, the depth and volume of those waters, depressed a few inches only, would be quite enough to account for any tide-wave which springs from a bosom so vastly capacious. Yet the sum of water so displaced temporarily, and restored to its place again, is merely a trifle compared to the immense source from whence it is drawn. But the economy of physical laws are not the less obvious. Oceans and seas are scoured out, new land formed, and previous land defended in its position. In limited seas like those we are acquainted with, the tide-wave appears prodigious, and we are apt to apply its giant-like bounds to every shore on the face of the globe. Whereas, the tidal phenomena of the earth is exceedingly trivial, compared with the extent we ordinarily assign to its course. Estimated in details, it seems an affair of currents and counter-currents in disorderly action. But we no sooner trace the tide-wave from the general motion of the earth, centered on the South Pole, than its movements take a comprehensive course, and assume perfect order and harmony divine, worthy of a universal architect—ever distributing his materials to the greatest advantage, and reducing fancied taste and ideal beauty to strict forms of conservation, adapted to the purposes designed.

In what we have here written, an anxious wish has been kept in view, to retain rather than controvert received doctrines and opinions. Unalterable truths ought not to be suppressed in the meantime, and frittered away in such a spirit. The doctrines of the attraction of gravitation and of cohesion, even as treated in these pages, are probably carried far enough. If active atoms be engaged in repelling inert particles of matter, or indivisible aggregates of atoms, the repelling force of the latter might not be according to their density, but coincident with their surface and volume, as previously expressed. Resistance being a main ingredient in the terms required, inert particles naturally acquire weight or density according as they are pressed upon by fluid or active force in matter. The generalization of such a doctrine, is certainly copied from, and at the same time evinced by those laws of fluidity, which hold so conspicuous a place in geological phenomena. The activity of fluids has scoured out the basins of the great deeps themselves, the resisting forces of denser materials have fixed the limits of the ocean, and contributed to the preservation and augmentation of dry land. Resistance, however, may not altogether depend on some mere principle of density, but upon the extent of space occupied, and the compact adherence of materials to each other. Repulsion by the force of active matter, therefore, and a counter repulsion by the inert particles thereof may constitute the primary laws of the universe, for similar reasons that they have decided geological depositions. Gravitation would in such a manner be determined by the laws of universal repulsion and resistance. Each member of the planetary system would therefore repress and drive back active particles of matter, and press upon and against one another according to the areas of their several surfaces, or like the gulf stream of the Atlantic performing its ceaseless revolutions from shore to shore. Density and weight might in some measure arise out of this plain law. Hence its weight might not be the solid materials of which it were composed, but the pressure brought upon it. By weight indeed, nothing more is meant than the degree of pressure denoted. For similar reasons, may not the repulsion of gravitation constitute a primary law of the universe, instead of the mystic riddle of the attraction of gravitation? It is true the term rests upon matter of fact. But is it not intended to convey an idea in addition to a fact. It is to an unknown something more that we object. If the shores of the Atlantic press upon each other through the medium of active and fluid matter, may not the planetary system do the same in reference to each other?

We repudiate the wish, however, of putting forth these doctrines in a dogged manner, and may, like others, sin occasionally, in handling too freely topics so vast and intricate to deal with. The progress of sound knowledge denies a spirit so objectionable. Having framed our ideas coincident with the phenomena of the attraction of gravitation in a qualified sense, we are ready to listen to the evidences and laws which facts assert. Our aim is not therefore, to prejudice the great question before us, but to leave it open to new and brilliant discoveries yet to be made. Let it once be fairly ascertained in how much chemical operations depend upon the figure, divisibility, and other properties belonging to particles of matter, then science may assume more of a mathematical character, and become infinitely less mystical and complex. Moreover, the affinities of matter might follow the same train of investigation. Because the particles of some bodies are small and active; and others larger and more inert, it does not follow that they may be unfitted for admixture and amalgamation, but the reverse. In this view experiment and inference have yet a brilliant field to open out, by careful watchings, by cautious inductions, and bold speculations reduced to rigid proofs. Dr. Dalton has already led the way; optics have thrown much light on crystalization, and a little more light gained, may soon lead to new and brilliant discoveries.

In closing this portion of our subject we would suggest that, could it be shown that a perceptible difference in the activity of particles of matter were attainable by dry or wet grinding, and which pounding failed to impart, it might possibly be inferentially ascertained, how much depended upon the figure and divisibility of atoms or particles, as well as upon their difference in volume and density. In short, it is plain that laminated particles cannot be so active and fluent as spherical ones. May not the figure of particles of matter be therefore intimately concerned with the causes of density in some bodies, and fluidity in others? Could it be shown experimentally, and the fact cannot be doubted, that misshapen particles are the proper bases of dense compounds, and that spherical particles are the better fitted for fluidity and activity, it might lead to important discoveries at a future day.

Nor does it follow that because atoms are laminated, they are unfitted for fluidity; but the opposite, and they have a strong tendency to fly upwards.

—because they would be rendered light and airy. In such atoms we certainly could not expect to find the properties of force. The truth probably may be that the sun, as the mighty centre of the solar system, moving on its axis, and carrying the planetary system periodically around its vortex, may be engaged in preparing spherical atoms which are continually flying off, and receiving back again laminated ones, which have taken a light and airy form. We do not assert that this is so, we only state it hypothetically to show how much deeper the economy of the universe may be than any of the trivial sources of knowledge we have yet mastered.

The irrespirable properties of hydrogen gas, and its peculiar lightness, may be owing to its having been hammered into laminated atoms on our earth, in order that it may be re-despatched to the sun, there to be reconstructed in a spherical, and returned to earth again in an electrical form. Grant these speculations to be as idle as we may choose, and in reference to absolute truths, they are certainly idle enough, still our illustration holds good. Namely, that the various members of the solar system carry on a mighty manufactory of atoms, which are intended to perform essential offices in the vast economy and fabrication of the universe. All the evidences we are acquainted with, favour an hypothesis so consistent with what we know; and while those speculations are put forth somewhat too freely, the aim is by no means that of a baseless originality; but with a view of bringing philosophical experiments under a set of tests that may possibly shed a ray of light upon physical researches in general, by showing how much depends upon the figure, density, volume, surface, and divisibility of atoms.

Divisibility is the natural order of matter. All substantial being has a tendency to resolve itself into the most bodyless forms. But the very truth of this comprehensive law in physics, is the origin of physical forces, the cause why matter is driven into clusters, and exhibits itself in solid bodies like our earth, or those massive globes which form the various members of the planetary system. Yet we shall not, in the mean time, urge the doctrine here stated any further.

Such properties in the material of existence are obvious; and those materials are the substance of the universe. It is at the same time balanced with mathematical certainty. What is balanced? Those materials of which the universe is composed. Here Philosophy may properly commence in considering the figure, divisibility, and properties of the various particles of matter, first in themselves, and next in compounds. Then causes of light and darkness may appear. The economy of Providence lies before us; and the elements of infinite wisdom are scattered around us, above our heads, and beneath our feet. Do we tremble at the awfulness of the investigation? Surely not. Every step we take in ascertaining physical truths, assures us of the wisdom, the power, and the beneficence of an eternal, an omnipotent, and an omniscient God—the author of all goodness, might, dominion, and power.

Can we witness his vast providential means, in preparing and dealing with materials, scattered around us in every direction, and refuse to gain a knowledge of their utility? They are not hidden from us—they are intended for our use. The more justly and soberly we estimate them, the more grateful and obedient to the donor we are likely to be. Bewildered philosophers may tell us that the world waxes more barren and cold in our hands; whilst the earth teems with endless means of plenty and human felicity. Agriculture is yet an infant art—commerce is every day bringing new conveniences around our homes—civilization is rendering up better securities to person and property—barbarism is laid prostrate—despotism subdued, and licentiousness lies spell-bound in the realms of a happy and contented people.

To crown those great and marvellous works—Religion sheds its divine influence around us. To what shall we attribute all this?—To chance—to mere necessity—to delusion? No! To the foreknowledge, design, and goodness of an all-wise Providence. In saying thus much, we seek not to put forth mysteries and delusions. Nor is the author of these pages for a moment afraid to state truths, because he humbly believes in his heart that actual truth is the surest vindicator and propagator of the high purposes of Heaven.

Sound knowledge by no means leads to infidelity and scepticism, but the reverse. Were it so, then

> "The poor Indian whose untutor'd mind
> Sees God in clouds, or hears him in the wind,"

should surpass in Christian belief, and in the practice of Christian principles the votaries of science. But, no! The rational influence of religious and moral sentiments in which we believe, settles such a question in favour of the progress of knowledge most undeniably. We grant that a little learning may prove dangerous. Yet more exact and enlarged information unfailingly contributes to reclaim lost truth, and re-establish more sober conceptions in the mind of man. That this may be the effect of a better acquaintance with Geological truths is what we firmly believe, as evinced by a statement of the most obvious facts. Nothing could have been more skilfully devised than the skeleton of the earth given in the foregoing pages. The more we study its influence in accordance with physical laws, the more are we convinced of the infinite wisdom by which it has been projected, and the correctness of that intelligence and those powers by which it has been carried into effect.

THE END.

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